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A. M. SHELTON, *Director*

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STATE GEOLOGICAL SURVEY

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REPORT OF INVESTIGATIONS—NO. 13

STRATIGRAPHY AND GEOLOGIC STRUCTURE OF
NORTHERN ILLINOIS
WITH SPECIAL REFERENCE TO UNDERGROUND
WATER SUPPLIES

BY
F. T. THWAITES

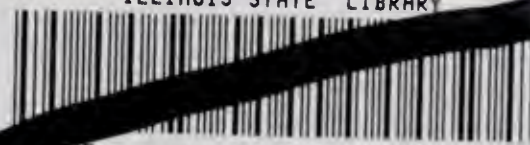


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P R E F A C E

The accompanying report on Stratigraphy and Geologic Structure of Northern Illinois with Special Reference to Underground Water Supplies has been in the process of preparation for some time. Most of the buried rock formations of northern Illinois have been studied in surface exposures in Wisconsin by the author, Mr. F. T. Thwaites of the Wisconsin Geological and Natural History Survey, and the Illinois State Geological Survey has been fortunate in securing his interest in the study of the well cuttings of a large number of wells in that part of the State. Mr. Thwaites has also given much attention to the application of geologic knowledge to well drilling for water recovery. It is therefore believed that this report will be helpful to those seeking information regarding the geologic conditions of northern Illinois from the standpoint of underground water supplies.

The report has had the benefit of a careful review by Mr. G. C. Habermeyer, Engineer of the Illinois State Water Survey, which both the author and the Illinois State Geological Survey gratefully acknowledge.

M. M. LEIGHTON, *Chief,*
State Geological Survey Division.

STRATIGRAPHY AND GEOLOGIC STRUCTURE
OF NORTHERN ILLINOIS

WITH SPECIAL REFERENCE TO UNDERGROUND WATER SUPPLIES

By F. T. Thwaites

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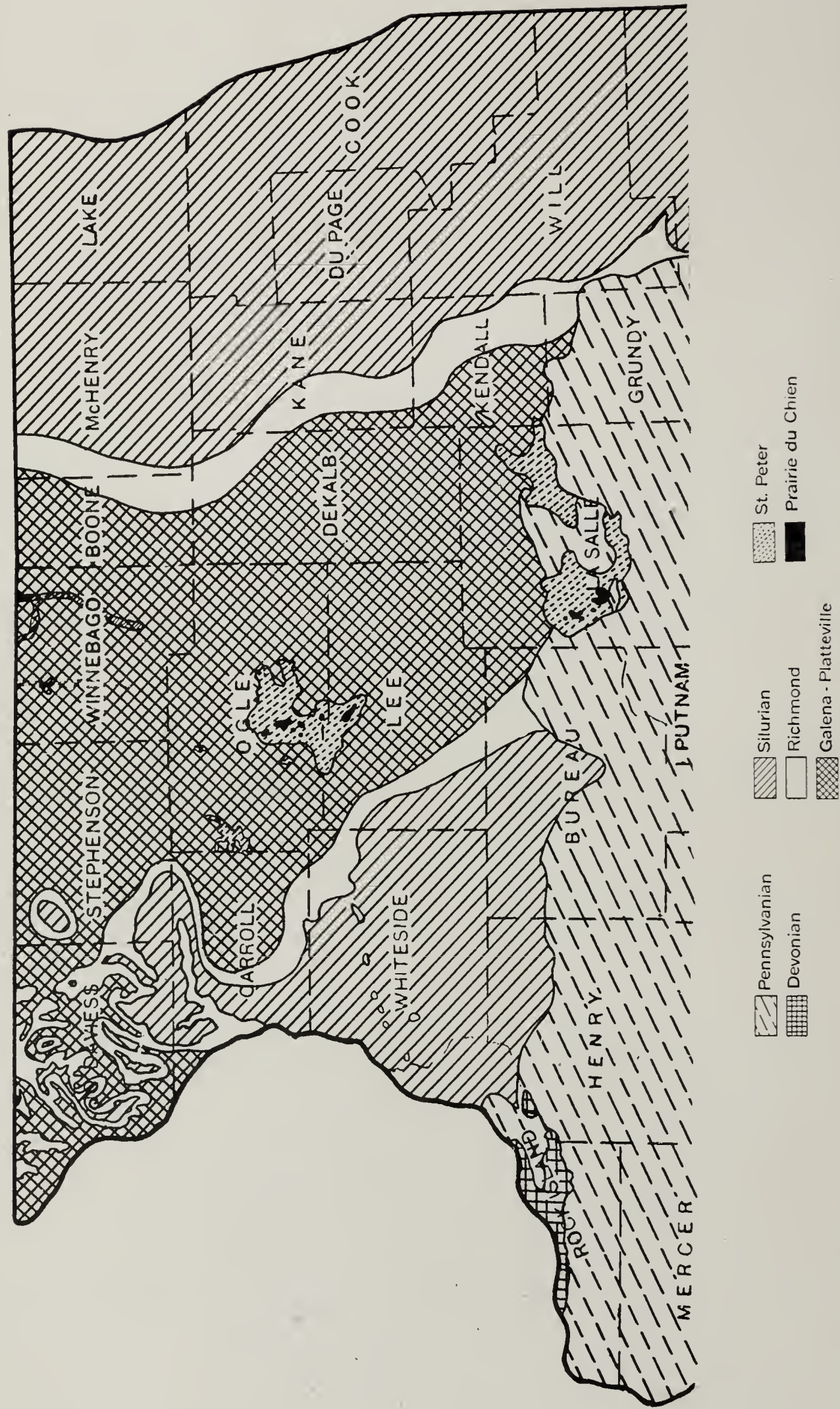


Fig. 1. Sketch map of aerial geology of northern Illinois.

INTRODUCTION

Potable underground waters can be obtained in quantity throughout northern Illinois. They form an important resource which is utilized by many industries, cities, villages, and individuals. Very few cities of the size of Chicago have as large supplies of potable underground water. Rockford is the largest city in Northern Illinois to use well water for its public supply.

The subject of underground waters in northern Illinois has been investigated by a number of geologists and engineers.¹ The attention of the writer was drawn to the district in connection with studies in Wisconsin and the correlation of the deeply buried formations was announced in 1923.² To simplify forecasting of depths to the Cambrian sandstones a structure map was made (Pl. I). The present paper is designed primarily as an aid to engineers and well drillers.

GEOLOGICAL FORMATIONS AND THEIR WATER SUPPLIES

GENERAL STATEMENT

North of the 41st parallel of latitude Illinois is underlain beneath the soil and loose surface material by rocks of the Pennsylvanian, Devonian, Silurian, and Ordovician systems. (See fig. 1.) Cambrian rocks may underlie parts of the Rock River valley but are elsewhere concealed under younger formations. In the far northwestern part of the State the mantle rock or "surface" was mainly formed by weathering of the bed rocks, in part was deposited by the wind, and in the valleys was laid down by streams. In the remainder of the district the mantle rock was deposited by glaciers with associated streams and lakes; these deposits are collectively known as "drift". The bed rocks alone are discussed in this report. The names of the different formations are those used in 1926 by the Illinois State Geological Survey. For the convenience

¹Stone, Leander, The artesian wells of Chicago: Chicago Acad. Sci. Bull. 1, pp. 93-102, 1886.

Rolfe, C. W., Artesian water from the drift in eastern Illinois: Am. Geologist, vol. 6, pp. 32-35, 1890.

Mead, D. W., Notes on the hydrology of Illinois in relation to its water supplies: Illinois Soc. Engr. Rept., vol. 8, pp. 48-68, 1893.

Mead, D. W., The hydro-geology of the upper Mississippi Valley and of some of the adjoining territory: Assoc. Engrs. Soc. Jour., vol. 13, pp. 329-396, 1894.

Leverett, Frank, The water resources of Illinois: U. S. Geol. Survey Seventeenth Ann. Rept., pt. 2, pp. 695-828, 1896.

Shufeldt, G. A., Jr., History of the Chicago artesian well, Chicago, 1865, Religio-Philosophical Publishing Assoc., Chicago, 1897.

Udden, J. A., A new well at Rock Island, Illinois: Am. Geologist, vol. 21, pp. 199-200, 1898.

Rolfe, C. W., The geology of Illinois as related to its water supply: Univ. of Illinois, Chem. Survey of the Waters of Illinois, Rept. 1897-1902, pp. 41-56, 1903.

Udden, J. A., Geological classification of the waters of Illinois: Illinois State Geol. Survey Bull. 10, pp. 8-21, 1909, and Illinois State Water Survey Bull. 4, pp. 8-21, 1909.

Anderson, C. B., The artesian waters of northeastern Illinois: Illinois State Geol. Survey Bull. 34, 1919.

McClenahan, W. T., Predicting the results of deep well borings: Illinois Soc. Engrs., Proc., vol. 38, pp. 37-47, 1923.

Habermeyer, G. C., Public ground-water supplies in Illinois: Illinois State Water Survey Bull. 21, 1925.

²Thwaites, F. T., The Paleozoic rocks found in deep wells in Wisconsin and northern Illinois: Jour. Geology, vol. 31, pp. 529-555, 1923.

of those who have not followed all of the changes in usage of geologic names, a table (Table 1) has been prepared, in which the use of formation names in different reports on Illinois and adjoining states is compared. The description of formations in this report is confined to data from well logs and does not include a discussion of their paleontology and exact correlation. Each formation is illustrated by typical well records from the region here discussed. In quoting records by others some of the wording has been slightly changed to correspond with the usage in the data collected by the writer.

PENNSYLVANIAN SYSTEM

MCLEANSBORO, CARBONDALE, AND POTTSVILLE FORMATIONS

DESCRIPTION

Rocks of the Pennsylvanian system are known as the “Coal Measures” or the Upper Carboniferous. Formations of this age under-

TABLE 2.—Generalized section of Pennsylvanian rocks of La Salle County^a

Description of strata	Thickness <i>Feet</i>	Depth <i>Feet</i>
McLeansboro formation		
Shale, and clay, red, yellow, and blue, with limestone nodules	24	24
Coal	1	25
Shale, and clay, olive, yellow, and black, with gray, shaly limestone	19	44
Coal and fire clay	1	45
Shale, blue and brown.....	25	70
Limestone, gray with layers of blue and gray shale.....	29	99
Limestone, blue	5	104
Shale, hard, black, with thin coal at base.....	7	111
Shale, blue, with layers of blue limestone.....	24	135
Coal and fire clay.....	1	136
Shale, blue, with layers of gray limestone.....	69	205
Shale, brownish red to brown, with thin limestone seams...	17	222
Sandstone	18	240
Shale, black, slaty and in part sandy.....	36	276
Coal and fire clay.....	11	287
Shale, dark brown.....	16	303
Sandstone	34	337
Carbondale formation		
Shale, black	10	347
Coal and fire clay.....	10	357
Shale, sandy	30	387
Sandstone, varies from 15 feet to.....	35	422
Shale, brown, olive, blue, gray, and black, with thin layers of shaly limestone, and shaly, calcareous sandstone....	83	505
Coal and fire clay.....	5	510
Pottsville formation		
Sandstone	6	516
Shale, gray and dark gray.....	124	640
Sandstone, white	40	680
Shale light gray.....	36	716
Sandstone, fine to very fine grained, gray.....	20	736
Shale, blue to green, sandy.....	25	761
Total Pennsylvanian	761 feet	

^aAdapted from Cady, G. H., Coal resources of district I (Longwall): Illinois Coal Mining Investigations Bull. 10, pp. 124-126, 1915.

System	Northern Illinois 1927	Not	Iowa, 1912 ^e Minnesota, 1911 ^f	Minnesota 1900 ^g
Devonian	Sweetland Creek Cedar Valley Wapsipinicon		Sweetland Creek Cedar Valley Wapsipinicon	Hamilton Marcellus? Corniferous
Silurian	Niagaran Alexandrian	Niag Alex	Niagara	
Ordovician	Richmond group Maquoketa	Maqu	Maquoketa	Hudson River
	Galena Decorah Platteville	Galena Platteville	Galena Decorah Platteville	Galena Trenton
	St. Peter	St. Peter	St. Peter	St. Peter
	Prairie du Chien group Shakopee "New Richmond" Oneota	Prairie Shakopee New Richmond Oneota	Shakopee New Richmond Oneota	Shakopee New Richmond Lower Magnesian
Cambrian	Jordan ^j		Jordan	Jordan
	Trempealeau ⁱ			
	Mazomanie		St. Lawrence	St. Lawrence
	Franconia			
	Dresbach	Jordan	Dresbach and undifferentiated Cambrian	Dresbach
	Eau Claire	St. Lawrence		Hinckley
	Mt. Simon	Dresbach		

^aAnderson, C. B., The artesian waters of northern resources of Iowa: U. S. Geol. Survey Water-Supply Paper 293, II, 1919.
^bDoes not show new geologic systems proposed by Ulrich, E. O., Notes on new names in table of Paleozoic systems in Wisconsin: Wisconsin Acad. Sci. vol. 6, Map of state, 1901.
^cThwaites, F. T., The Paleozoic rocks found in de by Ulrich; it is the opinion of the writer that it is equivalent to vol. 31, pp. 529-555, 1923.
^dWeidman, Samuel, and Schultz, A. R., The unde proved by the Board of Geologic Names of the U. S. Geol. Survey. Geol. and Nat. Hist. Survey Bull. 35, Pl. II, 1915. part of Illinois.
^eChamberlin, T. C., Geology of Wisconsin, vol.

TABLE 1.—Correlation table of geologic names used in Illinois and adjacent states

System	Northern Illinois 1927	Northeastern Illinois 1919 ^a	Wisconsin 1923 ^b	Wisconsin 1915 ^c	Wisconsin to 1915 ^d	Iowa, 1912 ^e Minnesota, 1911 ^f	Minnesota 1909 ^g
Devonian	Sweetland Creek Cedar Valley Wapsipinicon		Milwaukee	Milwaukee (Hamilton)	Hamilton	Sweetland Creek Cedar Valley Wapsipinicon	Hamilton Marcellus? Corniferous
Silurian	Niagaran Alexandrian	Niagaran Alexandrian	Waubakee Niagaran series—Guelph, Racine, Waukesha, Byron, Mayville	Waubakee Niagaran series	Salina Niagara	Niagara	
Ordovician	Richmond group Maquoketa	Maquoketa	Richmond group Maquoketa	Richmond group Maquoketa	Cincinnati	Maquoketa	Hudson River
	Galena Decorah Platteville	Galena Platteville	Galena-Black River groups Galena Decorah Platteville, Beloit	Galena Decorah Platteville	Galena Trenton	Galena Decorah Platteville	Galena Trenton
	St. Peter	St. Peter	St. Peter	St. Peter	St. Peter	St. Peter	St. Peter
	Prairie du Chien group Shakopee "New Richmond" Onkota	Prairie du Chien group Shakopee New Richmond Onkota	Lower Magnesian group Shakopee Onkota	Lower Magnesian group Shakopee Onkota	Lower Magnesian	Shakopee New Richmond Onkota	Shakopee New Richmond Lower Magnesian
			Madison				
Cambrian	Jordan ^j		Mendota, Devils Lake ^h	Madison (Jordan)	Madison	Jordan	Jordan
			Jordan				
	Trempealeau ⁱ		Trempealeau ⁱ	Mendota (St. Lawrence)	Mendota		
	Mazomanie Franconia		Mazomanie Franconia	Franconia		St. Lawrence	St. Lawrence
	Dresbach	Jordan ^j	Dresbach	Dresbach	Potsdam		
	Eau Claire	St. Lawrence	Eau Claire	Eau Claire		Dresbach and undifferentiated Cambrian	Dresbach
	Mt. Simon	Dresbach	Mt. Simon	Mt. Simon			Hinckley

^aAnderson, C. B., The artesian waters of northeastern Illinois: Illinois State Geol. Survey Bull. 34, Plate II, 1919.

^bDoes not show new geologic systems proposed by Ulrich.

Ulrich, E. O., Notes on new names in table of formations and on physical evidence of breaks between Paleozoic systems in Wisconsin: Wisconsin Acad. Sci. Trans., vol. 21, pp. 71-107, 1924.

Thwaites, F. T., The Paleozoic rocks found in deep wells in Wisconsin and northern Illinois: Jour. Geology, vol. 31, pp. 529-555, 1923.

^cWeidman, Samuel, and Schultz, A. R., The underground and surface water supplies of Wisconsin: Wisconsin Geol. and Nat. Hist. Survey Bull. 35, Pl. II, 1915.

^dChamberlin, T. C., Geology of Wisconsin, vol. 1, pp. 119-212, 1883.

^eNorton, W. H., et al, Underground water resources of Iowa: U. S. Geol. Survey Water-Supply Paper 293, Pl. II, 1912; Iowa Geol. Survey, vol. 21, pp. 29-1186, 1912.

^fHall, C. W., et al, Geology and underground waters of southern Minnesota: U. S. Geol. Survey Water-Supply Paper 256, Pl. VI, 1911.

^gWinchell, N. H., Geology of Minnesota, vol. 6, Map of state, 1901.

^hThe Mendota is assigned to this position by Ulrich; it is the opinion of the writer that it is equivalent to the lower part of the Trempealeau, the original "St. Lawrence."

ⁱThe name Trempealeau has not been approved by the Board of Geologic Names of the U. S. Geol. Survey.

^jFormation present only in northwestern part of Illinois.

lie only the southern part of the area here described. (See fig. 1.) They have been divided, in descending order, into the McLeansboro, Carbon-dale, and Pottsville formations which are all composed of: gray to black shale which is in part calcareous, and much of which is very pyritic; impure, shaly, brownish-gray, pyritic, calcareous sandstone; gray, calcitic limestones; and coal. The relative proportions of these rocks vary much within short distances. The thickness reaches a known maximum of about 760 feet in this region but is much less in most of the area. The generalized section in Table 2 shows the character of the Pennsylvanian formations.

WATER SUPPLIES

The greater part of the Pennsylvanian rocks are impervious or yield little water the quality of which is notoriously poor. In all but a few places near the outcrop of a water-bearing layer, salt and hydrogen sulphide make the water unfit for most uses. This condition is apparently explained by (1) the discontinuity of the porous strata which has prevented thorough flushing of the soluble minerals, and (2) the presence of pyrite and carbon. Inasmuch as the Pennsylvanian rocks rest upon several of the underlying formations, the water in the latter is contaminated in many localities which are adjacent to such contacts. Exploration for potable water in the Pennsylvanian rocks and in formations which are in contact with water-bearing layers in them cannot be recommended where other sources are possible.

DRILLING CONDITIONS

Most of the Pennsylvanian rocks offer no unusual difficulty to well drilling so far as the experience of the writer has shown. Some of the shales, particularly the fire clays, swell or disintegrate to clay when wet but most of the rocks do not cave to an unusual extent. Locally old caved mine workings may be encountered. On account of the character of the water it is absolutely necessary to case off all of the Pennsylvanian formations.

DEVONIAN SYSTEM

SWEETLAND CREEK SHALE, CEDAR VALLEY LIMESTONE, AND WAPSIPINICON LIMESTONE

Devonian rocks outcrop only in the vicinity of Rock Island. They consist of brown and black shale, and white, gray, and blue, more or less shaly limestones and dolomites. The total thickness does not exceed 300 feet. These rocks contain some water near the base especially in Mercer County. They offer no unusual drilling difficulty. The log in Table 3 may include some of the underlying Silurian.

TABLE 3.—*Well log illustrating character of Devonian rocks*

Partial log of city well No. 2, Aledo, Mercer County		
	Thickness	Depth
	<i>Feet</i>	<i>Feet</i>
		135
Shale, brownish gray, fossiliferous.....	130	265
Dolomite, light gray, dark spots, pyritic, in part oolitic, fossiliferous	20	285
Limestone, light gray	65	350
Shale, light gray	5	355
Limestone, light gray	10	365
Dolomite, light gray to white.....	63	428
Shale, gray, dolomitic, logged as "black slate".....	2	430
Total Devonian 295 feet		

SILURIAN SYSTEM

NIAGARAN DOLOMITE, KANKAKEE LIMESTONE, AND EDGEWOOD FORMATION
(NIAGARAN AND ALEXANDRIAN SERIES)

DESCRIPTION

The rocks of the Niagaran and Alexandrian series of northern Illinois consist mainly of light gray, more or less cherty dolomite. Toward the base, in the Alexandrian series, there are interstratified beds of green, pink, red, and blue dolomitic shales. These lower beds have been divided by Savage⁴ into the Kankakee limestone and the Edgewood formation. From the standpoint of the well driller it is hardly worth while to attempt to distinguish these thin formations but the base of the Silurian may be fixed at the bottom of the light-colored dolomites. The total thickness of the Silurian nowhere exceeds 500 feet and in the vicinity of Chicago is much less than that. The well logs in Table 4 indicate the character of the formations in various parts of the district.

TABLE 4.—*Well logs illustrating character of Silurian rocks*

(a) Partial log of city well No. 2, Aledo, Mercer County		
	Thickness	Depth
	<i>Feet</i>	<i>Feet</i>
		430
Dolomite, light gray.....	25	455
No sample, log shows same as above.....	10	465
Dolomite, bluish-gray, vesicular.....	10	475
Dolomite, light gray.....	85	560
Total Niagaran 130 feet		

⁴Savage, T. E., Alexandrian rocks of northeastern Illinois and eastern Wisconsin: Bull. Geol. Soc. America, vol. 27, pp. 305-324, 1916.

(b) Partial log of well No. 2, Mineral Point Zinc Company,
Depue, Bureau County^a

	Thickness <i>Feet</i>	Depth <i>Feet</i>
		388
Dolomite, white	10	398
Dolomite, dense, light gray.....	17	415
Dolomite, white, pyritic	7	422
Dolomite, light gray, some white chert.....	13	435
Dolomite, white, porous, white chert and quartz.....	35	470
Dolomite, white, soft, fine-grained, some quartz and white chert	50	520
Dolomite, gray and greenish gray, soft, some green clay.....	20	540
Dolomite, white, soft, fine-grained, white chert.....	15	555
Dolomite, light gray, soft, white chert.....	47	602
Dolomite, coarse-grained, buff	6	608
Dolomite, coarse-grained, buff, some dark gray and pyritic....	7	615
Dolomite, dense, light yellow, with some white rock, fossiliferous	17	632
Dolomite, light gray, porous, coarse-grained.....	18	650
Dolomite, fine-grained, white	23	673
Dolomite, buff, with some gray staining.....	27	700
Dolomite, dense, white	20	720
Dolomite, buff, coarse-grained, porous.....	17	737
Dolomite, gray, with some green and gray shale.....	28	765
Dolomite, gray to white, some white chert.....	77	842
Dolomite, gray, pyritic	8	850
Total Silurian (possibly including some Devonian) 479 feet		

^aUdden, J. A., Some deep borings in Illinois: Illinois State Geol. Survey Bull. 24, p. 49, 1914.

(c) Partial log of well of Abbott Laboratories, North Chicago, Lake County

		100
Dolomite, light gray, porous	10	110
Dolomite, white	80	190
Dolomite, gray, some dark gray clay.....	20	210
Shale, gray, very dolomitic.....	20	230
Dolomite, light gray	25	255
Dolomite, pink to pinkish gray.....	25	280
Dolomite, light gray	65	345
Dolomite, light and dark gray.....	5	350
Total Niagaran 250 feet		

(d) Partial log of A. D. Lasker well, Everett, Lake County

		154
Dolomite, white to gray	39	193
Dolomite, white to light gray, with white chert.....	35	228
Dolomite, light gray	20	248
Dolomite, light gray, with white chert.....	5	253
Dolomite, light gray and greenish gray.....	5	258
Dolomite, light gray with brown spots; white chert.....	10	268
Dolomite, white to light gray.....	90	358
Dolomite, dark gray to white.....	5	363
Dolomite, light gray, pyritic.....	15	378
Shale, green, dolomitic; dolomite, light gray.....	5	383
Dolomite, light gray	5	388
Dolomite, light gray and light greenish gray.....	10	398
Total Niagaran and Alexandrian 244 feet		

WATER SUPPLIES

The Silurian dolomites yield water mainly from cracks and to some extent from openings caused by solution. Quantities of as much as 1,100 gallons per minute have been reported in some localities but these are exceptional. The amount of water depends upon the local amount of fracturing of the formation. Near Chicago the water of many wells contains hydrogen sulphide.⁵ In some localities there are strong showings of oil whose presence renders the water undrinkable. Exploration for oil was once carried on in and near Chicago without securing commercial production.⁶ In later years a little oil and gas were found near Lake Forest.⁷ In view of the lack of an impervious capping over the dolomite and the universal presence of fresh water which implies thorough flushing of the formation, it is extremely unlikely that any large quantity of either oil or gas will ever be discovered. According to an average of 31 analyses⁸ the Niagaran waters of Cook County average less than 0.7 pound of encrusting solids per 1000 gallons and are therefore decidedly softer than the water of Lake Michigan which carries slightly more than one pound in the same quantity. Near La Salle, water with as little encrusting solid but considerable salt is ascribed to the same formation⁹ but such soft waters are not typical. Most Niagaran waters contain more than 3 pounds of encrusting solids per 1000 gallons. Anderson¹⁰ mentions several wells which were contaminated by the effluent from gas works, so that sewage contamination is possible in all wells where the glacial drift is thin or pervious.

DRILLING CONDITIONS

No unusual drilling conditions are likely to exist in the Silurian dolomites except incline fissures which may cause a crooked hole. When an intercepting tunnel was constructed at Argo to cut a number of wells at a depth of 357 feet the holes were all found to be out of vertical by amounts ranging from 6 inches to 11 feet.¹¹ It is recommended that all wells in large cities where the drift is thin be cased through the Silurian rocks in order to eliminate the danger of contamination as well as the objectionable hydrogen sulphide.

⁵Weiland, H. J., and Bartow, Edward, Hydrogen sulphide in the well waters of Chicago and vicinity: Illinois State Water Survey Bull. 13, pp. 359-368, 1916.

⁶Shufeldt, G. A., On an oil-well boring at Chicago: Am. Jour. Sci., 2d ser., vol. 40, pp. 388-389, 1865.

Hunt, T. S., On the oil-bearing limestone of Chicago: Canadian Naturalist, vol. 6, pp. 54-59, 1871.

Grant, U. S., Possible horizons for oil and gas in northeastern Illinois: Illinois State Acad. Sci. Trans., vol. 15, pp. 389-392, 1922.

Alden, W. C., U. S. Geol. Survey Geol. atlas, Chicago folio (No. 81), p. 13, 1902.

⁷Anderson, C. B., The artesian waters of northeastern Illinois: Illinois State Geol. Survey Bull. 34, pp. 185-186, 1919.

⁸Idem, p. 96.

⁹Cady, G. H., Geology and mineral resources of the Hennepin and La Salle quadrangle: Illinois State Geol. Survey Bull. 37, p. 126, 1919.

¹⁰Anderson, C. B., op. cit., p. 103.

¹¹Anonymous, Corn products water supply and underground pumps: Engr. News-Record, vol. 93, pp. 501-503, 1924.

ORDOVICIAN SYSTEM
MAQUOKETA SHALE (RICHMOND GROUP)

DESCRIPTION

The Maquoketa formation consists of bluish gray to greenish gray, rarely brown dolomitic shale with subordinate amounts of white to dark gray or blue dolomite, some of which is very shaly. In far northwestern Illinois there are some layers of calcitic limestone. The thickness varies from about 100 feet to nearly 200 feet. No attempt has yet been made to subdivide the formation. The amount of water is negligible. The well logs in Table 5 indicate the character of the Maquoketa.

TABLE 5.—*Well logs illustrating character of the Maquoketa shale*

(a) Partial log of village well, Grays Lake, Lake County		
	Thickness <i>Feet</i>	Depth <i>Feet</i>
		400
Shale, blue, dolomitic	30	430
Dolomite, dark gray, and shale, blue, dolomitic.....	10	440
Shale, blue, dolomitic	30	470
Dolomite, dark gray with light gray spots.....	20	490
Shale, blue, dolomitic.....	60	550
Total Maquoketa 150 feet		
(b) Partial log of A. D. Lasker well, Everett, Lake County		
		398
Shale, blue, dolomitic	25	423
Dolomite, gray and dark blue, pyritic.....	20	443
Shale, dark blue, hard, dolomitic; dolomite, gray.....	5	448
Shale, blue, dolomitic	80	528
Total Maquoketa 130 feet		
(c) Partial log of well drilled for Chicago Portland Cement Company Oglesby, La Salle County ^a		
		985
Shale, gray, calcareous	5	990
Limestone, gray, somewhat shaly	10	1000
Limestone, gray, subcrystalline	20	1020
Limestone, gray to bluish gray.....	20	1040
Shale, gray, rather soft	20	1060
Dolomite, gray, subcrystalline, some shale.....	25	1085
Dolomite, gray, subcrystalline	25	1110
Limestone, gray, subcrystalline	15	1125
Shale, gray, slightly calcareous	15	1140
Shale, gray, calcareous	10	1150
Total Maquoketa 165 feet		

^aCady, G. H., Coal resources of district I (Longwall): Illinois Coal Mining Investigations Bull. 10, p. 127, 1915. This log is based upon study of samples by T. E. Savage; another log, stated slightly differently, is given in a later publication, Cady, G. H., Geology and mineral resources of the Hennepin and La Salle quadrangles: Illinois State Geol. Survey Bull. 37, p. 30, 1919.

(d) Partial log of city well No. 2, Aledo, Mercer County

	Thickness <i>Feet</i>	Depth <i>Feet</i>
		560
Shale, blue, dolomitic	73	633
Dolomite, gray and blue, pyritic.....	15	648
Shale, blue, dolomitic	50	698
Shale, light brown, dolomitic	35	733
Shale, brown, very dolomitic, hard.....	10	743
Total Maquoketa 183 feet		

DRILLING CONDITIONS

The Maquoketa shales are very soft and drill easily but at times it is difficult to pick up the mud with the bailer. Sand or gravel poured into the hole often aids drilling. The collection of accurate samples is difficult because some of the cuttings form a thin mud which will not settle. Material stuck to the bit is not reliable, for it may have been scraped from the side of the hole while the tools were coming up. Masses of mud often stick to the side of the hole and later fall off. Washed samples are misleading since the dolomite and limestone beds are all interbedded with more or less shale. The entire formation should be cased off and it is best to place the casing before the well is drilled any deeper. A water-tight joint or "shut-off" must be made at the bottom of this string of pipe. In most wells this may be accomplished by the use of a shoe, for enough mud will settle around the pipe to seal it. The shut-off may be tested by bailing down the water inside the pipe to a level that is lower than it was before casing and watching the level over night to see that it is substantially stationary. Failures to effect a shut-off have been known to be due either to a crooked hole or to the fractures in the rock on which the bottom of the casing rested. The difficulty can be overcome by either drilling deeper to form a new shoulder or feeding mud or cement down the outside of the pipe while the water inside is bailed down.

GALENA AND PLATTEVILLE FORMATIONS (TRENTON AND BLACK RIVER GROUPS)

DESCRIPTION

The Trenton group is represented in northern Illinois by the Galena dolomite. This formation consists of gray, cherty, coarse-grained dolomite which weathers at the surface to a yellow sand-like consistency. Below the Galena in northwestern Illinois is a few feet of shale which is equivalent to the Decorah shale of Minnesota and Wisconsin. Beneath this shale, which is generally bituminous, is the Platteville formation of the Black River group. In the west this formation is calcitic limestone; to the east it gives way to dolomite of gray and blue colors, the equivalent of the Beloit formation of Wisconsin. In the northwestern and

central parts of the State, the base of the Platteville is marked by a brown and green shale and sandstone, the Glenwood member;¹² farther east it is marked by coarse- to medium-grained, dolomitic sandstone. Locally a layer of very dolomitic sandstone with a maximum thickness of 40 feet is found in the basal Platteville. This "stray sand" is separated from the St. Peter sandstone by 10 feet or more of some what sandy, gray dolomite. The basal Platteville is very pyritic. The thickness of the Galena and Platteville formations combined varies from a little less than 300 feet to as much as 450 feet. The well logs in Table 6 show the character of these formations which are not everywhere easily separated.

TABLE 6.—*Well logs illustrating character of Galena and Platteville formations*

(a) Partial log of well of Clinton Brewing Company, Clinton, Iowa ^a		
	Thickness <i>Feet</i>	Depth <i>Feet</i>
Galena formation		330
Dolomite, gray, crystalline, in part cherty.....	170	500
Dolomite, gray, cherty	10	510
Dolomite, gray or light buff; crystalline; in part vesicular..	55	565
Dolomite or magnesian limestone, brown, crystalline; with fossiliferous bituminous shale.....	5	570
Decorah (?)		
Shale, brown, highly bituminous and fossiliferous.....	5	575
Platteville formation		
Limestone, magnesian, brown	12	587
Limestone, magnesian, dark gray, subcrystalline, in part cherty	33	620
Limestone, bluish gray, dense, fossiliferous, thin bedded...	25	645
Limestone, light yellowish gray, soft, fossiliferous.....	5	650
Limestone, light bluish gray, fossiliferous.....	5	655
Shale, brown, bituminous; and limestone, dense.....	10	665
Shale, bluish green, pyritic, flaky.....	5	670
Total Galena-Platteville	340 feet	

^aNorton, W. H., et al, Underground water resources of Iowa: U. S. Geol. Survey Water-Supply Paper 293, p. 391, 1912.

(b) Partial log of city well No. 2, Aledo, Mercer County		
		743
Dolomite, light brown to gray.....	20	763
Dolomite, light gray	102	865
Dolomite, light gray with some white chert.....	85	950
Dolomite, white, white chert, pyritic.....	15	965
Dolomite, brown and gray, pyritic.....	30	995
Shale, greenish gray, dolomitic.....	5	1000
Limestone, brown, blue, and white.....	10	1010
Dolomite, gray, blue spots.....	55	1065
Total Galena-Platteville	322 feet	

¹²Bevan, Arthur, The Glenwood as a horizon marker at the base of the Platteville limestone: Illinois State Geol. Survey Rept. of Investigations No. 9, p. 6, 1926.

(c) Partial log of well drilled for Chicago Portland Cement Company,
Oglesby, La Salle County^b

		1150
Dolomite, gray, fine grained.....	35	1185
Limestone, magnesian, gray	40	1225
Limestone, gray, fine grained, some magnesium.....	85	1310
Limestone, gray, fine grained	55	1365
Limestone, gray, very fine grained.....	120	1485
Limestone, dark gray to light gray, very fine grained.....	10	1495
Limestone, gray, fine grained	25	1520
Total Galena-Platteville 370 feet		

^bCady, G. H., Coal resources of district I (Longwall): Illinois Coal Mining Investigations Bull. 10, pp. 127-128, 1915. Log based on examination of samples by T. E. Savage; a different log was published by Cady at a later date.

(d) Partial log of village well, Grays Lake, Lake County

	Thickness <i>Feet</i>	Depth <i>Feet</i>
		550
Dolomite, gray	100	650
Dolomite, gray, with a few blue spots.....	40	690
Dolomite, gray and buff, some blue spots; white chert.....	10	700
Dolomite, gray, with blue spots; white chert.....	40	740
Dolomite, gray, with some blue layers.....	10	750
Dolomite, dark gray, with blue spots.....	50	800
Dolomite, light gray, dark gray, blue and buff.....	30	830
Dolomite, dark gray, with blue spots.....	10	840
Sandstone, medium grained, white, calcareous.....	10	850
Sandstone, fine grained, white, calcareous; thin layers of gray, calcareous shale	30	880
Dolomite, light bluish, gray, very pyritic.....	10	890
Sandstone, very coarse, white; dolomite layers like above.....	10	900
Total Galena-Platteville 350 feet		

WATER SUPPLIES

Except on the outcrop, and along the La Salle anticline where there has been much fissuring, the Galena and Platteville formations yield little water. On account of the presence of pyrite, the water contains considerable amounts of sulphates; this fact explains the very hard scale formed when waters from these formations are used in boilers. Because of the comparative thinness of the formations, it is rarely advisable to stop drilling before the underlying St. Peter sandstone is reached. Shows of oil are not at all uncommon; a notable instance was reported at the Crotian Orphanage east of Des Plaines. There is a remote possibility of commercial production of oil should domes be discovered on the crest of the anticline north and northwest of Des Plaines, but it is probable that almost all of the oil that was once present has been washed out by fresh water.

DRILLING CONDITIONS

Unless it is desired to shut off some of the lower sandstones, the hole through the Galena and Platteville formations may be left uncased.

Presence of sand in the cuttings gives warning of the near approach to the St. Peter sandstone. The "stray sand" should not be mistaken for the St. Peter. It is coarser grained and more dolomitic than the St. Peter, breaks in chips, and contains no chert or red non-dolomitic shale. In disturbed zones, as near Des Plaines and La Salle, caving rock may be found in these formations.

ST. PETER SANDSTONE

DESCRIPTION

As found in wells, St. Peter is a light gray, less commonly pink or yellow, fine- to medium-grained, more or less dolomitic sandstone. A layer a few inches thick which is cemented by marcasite, a variety of iron sulphide, is found at the top in many places. Beneath the sandstone, which was originally defined as the St. Peter formation, is a variable thickness of red and green shale with pebbles of white and yellow chert, sandstone with chert pebbles, and some pink and gray dolomite. In some places only the chert-sandstone conglomerate is found. These basal beds were formerly referred to the Prairie du Chien formation but as they are material formed by its weathering and then re-worked by water it seems preferable to assign them to the younger formation. Including these beds, the thickness of the enlarged St. Peter varies from 50 to nearly 500 feet.¹³ In Wisconsin the absence of the St. Peter at many places is determined from rock outcrops and well records based on the study of samples. It is possible that it is absent in parts of Illinois since it is very thin in the Sears Roebuck well at Chicago. Table 7 illustrates the character of the St. Peter.

TABLE 7.—*Well logs illustrating character of the St. Peter sandstone*

(a) Partial log of city well, Galena, Jo Daviess County		
	Thickness <i>Feet</i>	Depth <i>Feet</i>
		155
Sandstone, medium grained, very light gray, pyritic.....	50	205
Sandstone, medium grained, light gray and pink.....	15	220
Sandstone, fine grained, light yellow.....	15	235
Sandstone, medium grained, pink, yellow, and white, no sample 265-275	50	285
Sandstone, pink; with red shale.....	30	315
Sandstone, brownish red; shale, green and purple; chert and some dolomite	20	335
Shale, purple and green layers; micaceous, hard; some sand....	10	345
Total St. Peter 190 feet.		

¹³If the record of an old well at Dixon given by Tiffany is correct this figure may reach 715 feet. Tiffany, A. S., Record of deep well at Dixon, Illinois: Am. Geologist, vol. 5, p. 124. 1890.

(b) Partial log of Chicago and North Western Railway well,
Malta, De Kalb County

		490
Sandstone, medium to fine grained, gray, dolomitic; some green shale	55	545
Sandstone, medium to fine grained, gray to white.....	55	600
Sandstone, medium to fine grained, yellow to gray.....	260	860
Shale, red; pebbles of white chert.....	5	865
Sandstone, medium to coarse grained, pink; pebbles of white chert	10	875
Sandstone, fine to medium grained, light gray; some light yellow quartzitic layers and pebbles of white chert.....	25	900
Shale, pink, very sandy; many pebbles of white chert.....	10	910
Sandstone, fine grained to medium grained, gray.....	5	915
Conglomerate; coarse to fine-grained sandstone with pebbles of white chert	5	920
Sandstone, coarse to medium grained, pink, shaly.....	25	945
Conglomerate, coarse to medium grained; white and pink sandstone with pebbles of white chert.....	5	950
Total St. Peter 460 feet.		

(c) Partial log of well of North Shore Country Club, Glenview, Cook County

	Thickness <i>Feet</i>	Depth <i>Feet</i>
		840
Sandstone, fine grained, gray, dolomitic	20	860
Sandstone, fine grained, gray	100	960
Conglomerate, pebbles of white chert in coarse to fine grained, gray sandstone; some gray, dolomitic shale	20	980
Conglomerate like above mixed with gray dolomite and shale...	10	990
Total St. Peter 150 feet.		

WATER SUPPLIES

The St. Peter sandstone is an important water-bearing formation near its outcrop in the north-central portion of the State but no longer yields large quantities of water in the Chicago district because of (a) its irregular thickness and (b) overdraft by the numerous wells in Chicago. As a result of oxidation of the pyrite and marcasite at the top of the formation and in the adjacent dolomites, the water contains considerable sulphate and rarely are less than 3 pounds of encrusting solids found in 1000 gallons. Where adjacent to water-bearing layers in the Pennsylvanian, as east of La Salle, the water carries some hydrogen sulphide. In localities where the St. Peter is thick and wells are widely separated, yields of 200 gallons per minute or more may be obtained.

DRILLING CONDITIONS

The top and bottom of the St. Peter are levels at which an unusual amount of trouble may be encountered in drilling. Many strings of tools have been lost soon after the St. Peter has been entered. Drilling proceeds without apparent trouble until the attempt is made to withdraw the tools which are then found to be stuck. Drillers ascribe this difficulty to the fact that the water level is in many places lower in the St.

Peter than in higher formations and the water runs down the hole carrying fine cuttings which settle around the tools or mud up the walls of the hole. Insertion of casing from the surface to the bottom of the Maquoketa shale with care to secure a good shut-off is said to remedy this difficulty. It is also advisable to make short runs, clean the hole thoroughly, and not drill continuously when the St. Peter is reached. Should the tools be lost, it is almost hopeless to attempt to withdraw them without clearing away as much of the debris as possible by drilling past the tools; this cannot be accomplished in holes much smaller than 8 inches in diameter since there is not room enough to permit the tools to swing sideways. An objection to holes less than 6 inches in diameter is that efficient fishing tools are not made for smaller sizes. The only way to fish a five-inch cable drill is to use a friction socket which does not take a firm hold. These difficulties do not apply to flowing wells where the water carries away the cuttings. The reason many old wells are of very small diameter is that pole tools were used and fishing was easier than with cable tools. Pole tools have, however, been abandoned on account of their many disadvantages.

Another danger zone is the shales and conglomerates at the base of the St. Peter. These can generally be drilled through without much caving, but unless the hole is cased at once either large chunks fall in or swelling reduces the size of the hole enough to cause trouble. This horizon is known to well drillers as "The Cave". Examination of rocks that have fallen into wells shows that the formations are filled with cracks and small faults.

It is difficult to determine in some places the point at which all of this kind of material has been passed through, since shale beds may be found in the underlying dolomites. In some wells casing has apparently not been inserted at once, for samples from underlying formations are contaminated with caved shale and chert. Most, if not all, of the chert ascribed to the Cambrian formations by some students of well records is unquestionably of such an origin. It is best to insert casing which rests on a shoulder as soon as it is apparent that the caving zone is safely passed. The work must be planned to allow for a reduction in the size of the hole and foresee the contingency that one reduction may not be enough. Underreaming in these formations is by all means to be avoided as it is very slow and troublesome.

SHAKOPEE, "NEW RICHMOND," AND ONEOTA FORMATIONS

(PRAIRIE DU CHIEN GROUP)

DESCRIPTION

The Prairie du Chien or Lower Magnesian group is divided in descending order into the Shakopee dolomite, the "New Richmond" sand-

stone, and the Oneota dolomite. These subdivisions cannot as yet be made in all parts of the State since the sandstone which separates the dolomites is not found at all points. In part the irregularity in the presence of the formations is accounted for by pre-St. Peter¹⁴ erosion which locally removed the entire group and appears to have destroyed the Shakopee formation over nearly all of the eastern part of northern Illinois.

The dolomites are mainly light gray in color but red, pink, or buff dolomite is found in some localities. White, yellow, and pink chert, both oolitic and dense, is common near the outcrop but is much less abundant at depth. Thin layers and specks of green shale are widespread and locally some red shale is found. Some layers are sandy and quartz-lined cavities are common. Some of the dolomite breaks under the drill into small regular chips which have been mistaken for sandstone by inexperienced drillers. It is an open question whether the medium-grained dolomitic sandstone near the middle of the group in the western part of the State is really the same as the original New Richmond sandstone of Minnesota. Near Dixon this sandstone contains red and green shale together with chert. It is difficult to fix the base of the group. At Glenview there is a sandstone which may be the Madison formation of Wisconsin. Some of the purple-spotted non-cherty dolomite of the basal Prairie du Chien of northeastern Illinois may be equivalent to the Mendota dolomite of Wisconsin but there appears to be no way to confirm the correlation. If it is correct, the Madison sandstone is absent in most of Illinois. In this report no attempt has been made to separate these beds of questionable age from the main body of the Prairie du Chien. In former reports (Table 1) this group was extended downward to include the sandy glauconitic strata here placed in the Mazomanie and Franconia formations. The strata of the Shakopee are in many places irregularly inclined, closely folded, and complexly faulted. The disturbances which caused the present attitude of the beds evidently antedate the deposition of the overlying St. Peter.¹⁵ The thickness of the Prairie du Chien group as defined in this report reaches a maximum of about 400 feet. In certain places, as at Lom-

¹⁴According to Sardeson (Sardeson, F. W., Shakopee dolomite and its cone domes: *Pan-Amer. Geologist*, vol. 45, pp. 29-48, 1926) the period of erosion was between the deposition of the Oneota and the Shakopee formations. He urges that the Shakopee consists of domes of dolomite separated by sandstone and shale, all of which are conformably overlain by what he calls the "Peter" sandstone. It is a fact that the Shakopee strata have never been seen to be truncated by the St. Peter beds but instead dip parallel to the irregular contact. The fact is indisputable that neither Shakopee nor Oneota dolomite is present beneath the St. Peter in many localities in Wisconsin and that the basal St. Peter gives indubitable evidence of long weathering of the underlying formations. In Wisconsin the St. Peter is known to rest upon all formations from the Shakopee to the Dresbach, a fact supported by outcrops and by well logs. Sardeson's claim that the Prairie du Chien is not absent at Galena because he has collected Shakopee fossils nearby is of no weight since the pinching out of the dolomites takes place in very short distances.

¹⁵Cady, G. H., The structure of the La Salle anticline: *Illinois State Geol. Survey Bull.* 36, pp. 109-112, 1920.

bard, Grays Lake, Rondout, and possibly part of Dixon, the entire group of dolomites is absent and the St. Peter rests upon the Cambrian. At Des Plaines no "third" dolomite is reported in the city well but its absence may be the result of faulting since the rocks are very much broken. The well logs in Table 8 illustrate the character of this group.

TABLE 8.—*Well logs illustrating character of the Prairie du Chien group*

(a) Partial log of well of Clinton Brewing Company, Clinton, Iowa ^a		
	Thickness <i>Feet</i>	Depth <i>Feet</i>
		730
Shakopee formation		
Dolomite, gray, sandy	23	753
Dolomite, gray; with layers of hard, dark gray shale.....	22	775
Dolomite, gray to bluish gray, pyritic.....	18	793
Sandstone, medium-grained, gray, with gray dolomite.....	7	800
Dolomite, light gray, dense, cherty and shaly.....	10	810
Dolomite, light gray, shaly, sandy	15	825
Dolomite, light to dark gray, coarse grained, porous, cherty	70	895
New Richmond (?) formation		
Dolomite, light gray, sandy	16	911
Sandstone, light gray, dolomitic, hard, fine grained.....	9	920
Oneota formation		
Dolomite, light gray, buff, and pink; white chert.....	70	990
Dolomite, buff, very fine, sandy.....	10	1000
Dolomite, light gray to bluish gray; cherty and sandy in some layers	75	1075
Total Prairie du Chien	345 feet.	
^a Norton, W. H., et al, Underground water resources of Iowa: U. S. Geol. Survey Water-Supply Paper 293, p. 391, 1912.		
(b) Partial log of well No. 2, Dixon Epileptic Colony, near Dixon, Lee County		
	Thickness <i>Feet</i>	Depth <i>Feet</i>
		182
Dolomite, fine grained, red and gray; top part caves.....	8	190
Dolomite, fine grained, gray	61	251
Dolomite, fine grained, gray, with soft, red, caving shale.....	11	262
Dolomite, gray, some pink; sandy gray pink, and yellow chert in part oolitic	143	405
Dolomite, reddish purple and brownish gray; some white chert..	37	442
Sandstone, medium grained, white; shale, green and dark red, caving; chert, oolitic, white and light brown.....	18	460
Dolomite, gray to light brown and pink, sandy; some red and green shale; chert, white and pink with quartz.....	140	600
Total Prairie du Chien	418 feet	
(c) Partial log of well of North Shore Country Club, Glenview, Cook County		
		990
Dolomite, gray	80	1070
Sandstone, fine grained, gray, very dolomitic.....	20	1090
Dolomite, gray, sandy	80	1170
Total Prairie du Chien	180 feet	

(d) Partial log of Mt. Carmel Cemetery well, Hillside, Cook County

		880
Dolomite, light gray, with green shale.....	10	890
Dolomite, light gray, with white chert and green shale.....	10	900
Dolomite, light gray, with some green shale.....	20	920
Dolomite, light gray, with white chert.....	10	930
Dolomite, light gray and pink	20	950
Dolomite, light gray, with green shale.....	30	980
Dolomite, very light gray; with white chert, oolitic and dense...	20	1000
Dolomite, gray and pink, sandy, green shade; oolitic white chert	30	1030
Dolomite, gray, sandy, pyritic.....	20	1050
Dolomite, light gray, with green shale.....	60	1110
Dolomite, gray, sandy	10	1120
Dolomite, light gray	50	1170
Dolomite, light gray, pyritic	10	1180
Dolomite, gray, some glauconite.....	10	1190
Total Prairie du Chien 310 feet, beds from 1110 to 1190 possibly Mendota		

WATER SUPPLIES

Where deeply buried the Prairie du Chien dolomites carry little water. Wells formerly in use to supply the village of Utica are supposed to depend for their supply mainly on water from the "New Richmond" sandstone and furnish water with about 2.7 pounds of encrusting solids per 1000 gallons.¹⁶ Other wells may draw a portion of their supply from this formation.

DRILLING CONDITIONS

The irregular and inclined layers near the top of the Prairie du Chien group where the Shakopee dolomite is present may cause much trouble by deflecting the hole. In some places, as near Dixon, caving layers of shale and broken dolomite have been found but rarely does a "cave" occur which is sufficiently bad to require immediate casing with reduction of the size of the hole.

CAMBRIAN SYSTEM

JORDAN AND TREMPEALEAU FORMATIONS

DESCRIPTION

The Jordan and Trempealeau formations are so closely related that they can be discussed together. Formerly the Jordan was defined as sandstone and the Trempealeau as sandy to pure dolomite but recently Ulrich¹⁷ has endeavored to confine the name Jordan to the coarser grained sandstone just beneath the Prairie du Chien dolomite excluding the fine-grained sandstone below. This has been objected to by

¹⁶Cady, G. H., Geology and mineral resources of the Hennepin and La Salle quadrangles: Illinois State Geol. Survey Bull. 37, pp. 124, 126, 1919.

¹⁷Ulrich, E. O., Notes on new names in table formations and on physical evidence of breaks between Paleozoic systems in Wisconsin: Wisconsin Acad. Sci. Trans., vol. 21, pp. 72-90, 1924.

Stauffer¹⁸ on the ground that it conflicts with the original definition of the Jordan. Irrespective of the merits of the controversy the older classification is preferable from the standpoint of the well driller. The Jordan sandstone thus defined is medium- to fine-grained and is wholly white or light gray in color; more or less dolomite is present and to both the south and east of its outcrop in western Wisconsin, northeastern Iowa, and southeastern Minnesota the formation grades laterally into sandy dolomite. The maximum thickness of the Jordan is about 60 feet in the western part of Illinois; no Jordan can be distinguished east of Dixon. The Trempealeau formation consists of nearly 200 feet of more or less sandy dolomite of gray, pink, and brown colors, and of red and gray dolomitic shale. Some glauconite is present. The thickness diminishes to the east and no Trempealeau has been distinguished east of Dixon. The well logs in Table 9 illustrate the character of the Jordan and Trempealeau formations.

WATER SUPPLIES

Although the Jordan sandstone is very important as a source of water in Iowa, the writer does not know of any large wells in Illinois that derive a significant part of their production from that formation. The nature of the Trempealeau formation indicates that it probably furnishes little water.

MAZOMANIE AND FRANCONIA FORMATIONS

DESCRIPTION

The Mazomanie and Franconia formations consist of fine- to medium-grained sandstone which is for the most part dolomitic and glauconitic. The colors are gray, green, pink, and red. In the far western part of the State there is some shale and sandy dolomite. In the

TABLE 9—*Well logs illustrating character of the Jordan and Trempealeau formations*

(a) Partial log of well of Clinton Brewing Company, Clinton, Iowa ^a		
	Thickness Feet	Depth Feet
		1075
Jordan formation		
Sandstone, fine grained, light gray, dolomitic, glauconitic, with layers of gray dolomite	15	1090
Trempealeau formation		
Dolomite, light gray, fine grained, rounded sand.....	30	1120
Sandstone, light gray, very fine grained, dolomitic.....	20	1140
Dolomite, buff; no cuttings recovered.....	70	1210
Dolomite, light brown, hard, medium grained.....	10	1220
Dolomite, some sand and glauconite, gray.....	10	1230
Dolomite, sandy, glauconitic, pink	10	1240
Dolomite, sandy, gray	30	1270
Dolomite, light pink, sandy, glauconitic	10	1280
Total Jordan and Trempealeau	205 feet.	

^aNorton, W. H., et al, Underground water resources of Iowa: U. S. Geol. Survey Water-Supply Paper 293, pp. 391-392, 1912.
¹⁸Stauffer, C. R., The Jordan sandstone: Jour. Geology, vol. 33, pp. 699-713, 1925.

(b) Partial log of city well, Galena, Jo Daviess County

Jordan formation		435
Sandstone, medium grained, white to gray, pink at base....	55	490
Trempealeau formation		
Dolomite, fine grained, sandy, brownish gray to light gray and pink	120	610
Total Jordan and Trempealeau	175 feet	

Chicago district much of the Mazomanie has been logged by drillers as either "lime" or "sandy lime" but examination of cuttings leaves no doubt that the rock is sandstone so well cemented by dolomite that it breaks into chips under the drill. Separation of the Mazomanie and the underlying Franconia is apparently not practicable in well records; the Mazomanie contains more sand and dolomite than the Franconia which is more shaly. There is probably no Franconia in the eastern half of Illinois. The combined formations vary in thickness from about 80 to nearly 150 feet. The logs in Table 10 illustrate the character of these rocks.

TABLE 10.—*Well logs illustrating character of the Mazomanie and Franconia formations*

(a) Partial log of city well, Galena, Jo Daviess County		
	Thickness <i>Feet</i>	Depth <i>Feet</i>
		610
Shale, light to medium green, slightly gritty, some mica and pyrite	10	620
Shale, green, calcareous, sandy, glauconitic	30	650
Sandstone, medium grained, gray, glauconitic, pyritic.....	10	660
Shale, light green, slightly calcareous, sandy, pyritic.....	20	680
Dolomite, fine grained, brownish gray, sandy glauconitic, pyritic	10	690
Total Mazomanie and Franconia	80 feet	

(b) Partial log of city well, Clinton, Iowa ^a		
	Thickness <i>Feet</i>	Depth <i>Feet</i>
		1355
Dolomite, pink, very fine, sandy, shaly, glauconitic.....	1	1356
Sandstone, exceedingly fine grained, shaly, dolomitic; dolomite, gray, glauconitic	14	1370
Sandstone, fine grained, glauconitic, with green shale.....	30	1400
Shale, greenish gray, very sandy, glauconitic	40	1440
Sandstone, fine grained, glauconitic, dolomitic; shale, sandy, red	5	1445
Total Mazomanie and Franconia	90 feet	

^aNorton, W. H., et al., Underground water resources of Iowa: U. S. Geol. Survey Water-Supply Paper 293, p. 385, 1912.

(c) Partial log of Chicago and North Western Railway well,
West Chicago, Du Page County^b

		1150
Sandstone, fine grained, gray to pink, dolomitic, with red dolomitic shale	25	1175
Sandstone, fine grained, light gray, with green dolomitic shale.	50	1225
Sandstone, coarse to medium grained, gray to white, dolomitic, glauconitic, breaks in chips	60	1285
Total Mazomanie 135 feet.		

^bSamples examined by R. C. Lentz, inspector.

(d) Partial log of well at St. Mary's Academy, Des Plaines, Cook County

		860
Dolomite, gray and light pink, sandy, glauconitic, pyritic.....	10	870
Sandstone, fine grained, pink, very dolomitic, glauconitic, pyritic, with pink, red, and green dolomitic shale.....	15	885
Sandstone, fine grained, gray and pink, very dolomitic, glauconitic	25	910
Sandstone, fine to very fine grained, very dolomitic, glauconitic.	35	945
Sandstone, very coarse to fine grained, with some pink dolomite and glauconite	20	965
Total Mazomanie 105 feet		

CORRELATION

The Jordan sandstone has been correctly recognized in northeastern Iowa and northwestern Illinois for a long time. The underlying formation now called Trempealeau was called St. Lawrence by the Iowa geologists. The sandstones beneath, now recognized as Mazomanie and Franconia, were included under the name St. Lawrence. In northeastern Illinois the very dolomitic sandstone here referred to the Mazomanie with confidence was formerly referred to the basal portion of the Prairie du Chien group (fig. 2), although Anderson¹⁹ was somewhat uncertain about this and thought possibly these strata might correspond with the Madison and Mendota formations of Wisconsin. The formations in question are characteristically glauconitic, and in fact constitute the most prominent glauconitic horizon in the entire section, whereas the Madison and Mendota are both low in glauconite. The Madison and Mendota are everywhere underlain by glauconitic sandstone instead of the pure white sandstone which is beneath the glauconitic beds of northern Illinois. It was suggested that this white sandstone is the Jordan but no place is known where the Jordan sandstone underlies the Mendota dolomite. The succession of a glauconitic-dolomitic sandstone underlain by a white sandstone is strikingly like the proved Mazomanie-Dresbach section of central and northeastern Wisconsin; the only difference is that the Madison sandstone pinches out to the south of Wisconsin and the Jordan sandstone to the east of

¹⁹Anderson, C. B., The artesian waters of northeastern Illinois: Illinois State Geol. Survey Bull. 34, pp. 84, 107, 1919.

Iowa. This fact is made certain by comparative sections drawn across northern Illinois and from the outcrops in Wisconsin south into Illinois.²⁰ In addition, the formations beneath the white sandstone here correlated as Dresbach are entirely unlike those below the proved Jordan sandstone.

WATER SUPPLIES

The Mazomanie and Franconia formations are for the most part too dense, fine grained, and dolomitic to furnish much water except where there are crevices. Anderson²¹ reports that such are present in the vicinity of Chicago. There is no available information on the quality of the water.

DRILLING CONDITIONS

No unusual drilling difficulties in the Mazomanie and Franconia formations have come to the attention of the writer. Problems arise when it is desired to set casing to the bottom of the Mazomanie sandstone. The rock at this level is in many places too soft to support the weight of the pipe. In order not to drill too deep to allow of making a shoulder on a firm layer, it is well to define the top of the formation and compute its base from records of thicknesses in adjacent wells. The top of the Mazomanie may be distinguished by the presence of glauconite, a dark green, soft mineral in small grains, and clear quartz sand in amounts making up a considerable portion of the rock. These substances may best be found by dissolving the cuttings in hydrochloric (muriatic) acid which is slightly heated in a glass or china dish; this treatment will cause the dolomite to dissolve with effervescence of carbon dioxide and the quartz and glauconite will be left plainly visible. Approach to the bottom of the Mazomanie may be distinguished by the presence of very coarse quartz grains and by reduction in the amount of dolomite which is made manifest by less effervescence with acid. It is the opinion of the writer that a shut-off may best be made when the first coarse sandstone is reached rather than at the true base of the formation. It would seem advisable to explore ahead with a hole of smaller diameter and then to ream down to a shoulder on a suitable hard layer.

DRESBACH SANDSTONE

DESCRIPTION

The Dresbach consists of medium-grained, pure white to yellow, or rarely pink sandstone. In few places is there any quantity of dolomite cement; a pink or yellow layer near the middle of the formation is not

²⁰Thwaites, F. T., The Paleozoic rocks found in deep wells in Wisconsin and northern Illinois: Jour. Geology, vol. 31, pp. 529-555, 1923.

²¹Anderson, C. B., op. cit., pp. 86, 89.

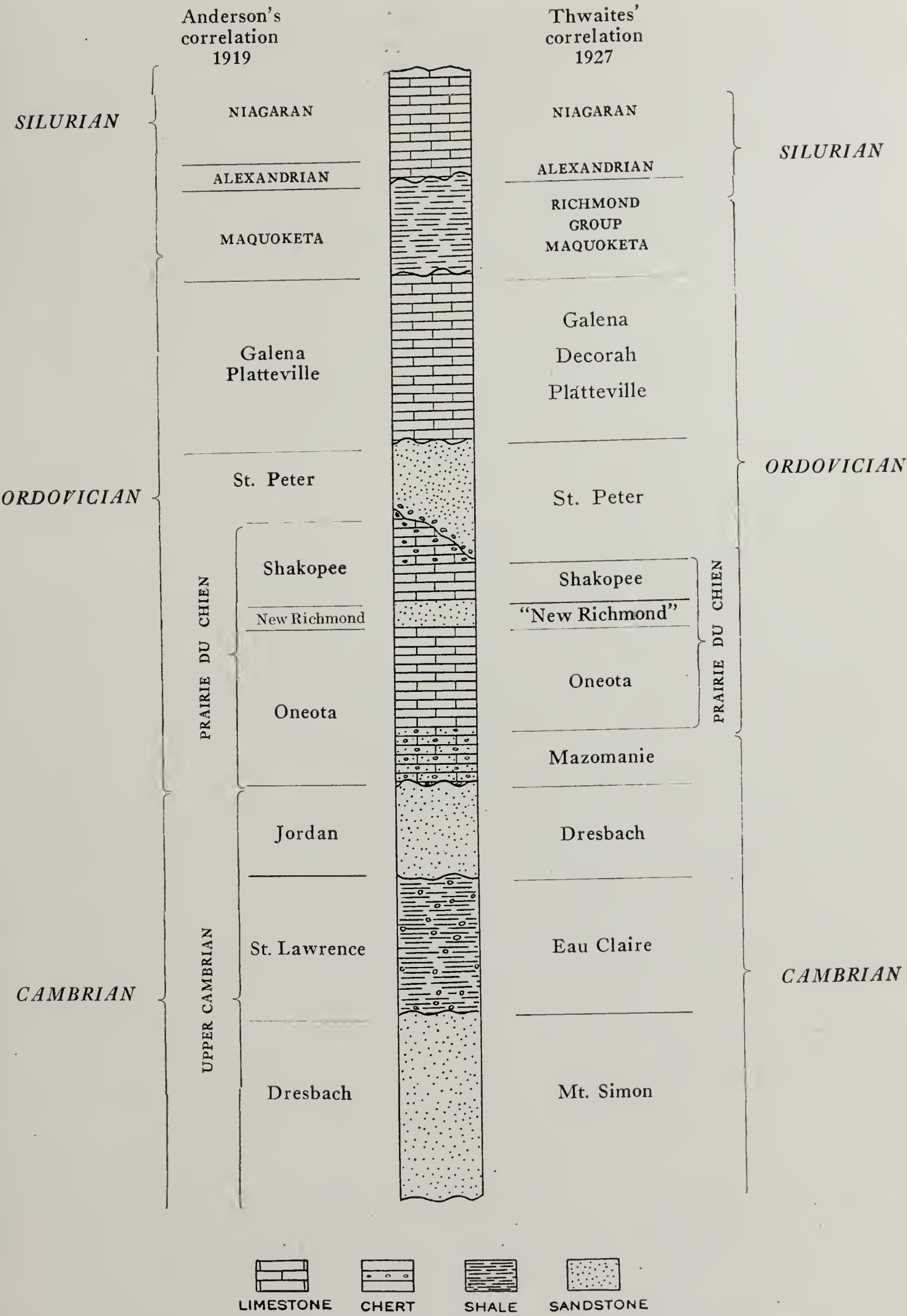


Fig. 2. Diagrammatic columnar section of northeastern Illinois showing revised correlation of strata.

uncommon. The top of the formation is easily recognized by the change in the color as well as by the softness of the rock. The thickness varies from 30 feet near Waukegan to nearly 200 feet to the south and west of that point. The logs in Table 11 illustrate the character of the Dresbach.

TABLE 11.—*Well logs illustrating character of the Dresbach sandstone*

(a) Partial log of city well, Galena, Jo Daviess County		
	Thickness <i>Feet</i>	Depth <i>Feet</i>
		700
Sandstone, medium grained, white.....	40	740
Sandstone, rather fine grained, light gray.....	100	840
Total Dresbach 140 feet		
(b) Partial log of city well, Clinton, Iowa ^a		
		1445
Sandstone, coarse grained, white.....	5	1450
Sandstone, fine grained, white.....	5	1455
Sandstone, coarse, pinkish gray	20	1475
Sandstone, fine grained, white	35	1510
Total Dresbach 65 feet		
^a Norton, W. H., et al. Underground water resources of Iowa: U. S. Geol. Survey Water-Supply Paper 293, p. 385, 1912.		
(c) Partial log of Chicago and North Western Railway well, West Chicago, Du Page County ^b		
		1285
Sandstone, coarse to medium grained, white.....	20	1305
Sandstone, coarse to fine grained, white and yellowish gray, dolomitic, hard	100	1405
Sandstone, medium to fine grained, white to light gray, dolomitic	25	1430
Total Dresbach 145 feet		
^b Samples examined by R. C. Lentz, inspector.		
(d) Partial log of village well, Grays Lake, Lake County		
		1200
Sandstone, medium grained, white	60	1260
Sandstone, fine grained, white	50	1310
Total Dresbach 110 feet		
(e) Partial log of city well, Elmhurst, Du Page County		
		1270
Sandstone, medium to fine grained, gray to white, slightly dolomitic	60	1330
Sandstone, fine grained, pink, dolomitic.....	10	1340
Sandstone, medium to fine grained, yellowish gray, dolomitic at top	50	1390
Total Dresbach 120 feet		

WATER SUPPLIES

The Dresbach sandstone is one of the best-known water-bearing formations in northern Illinois and is drawn upon by a very large number of deep wells. It is notable for its high porosity and freedom from objectionable substances such as dolomite, calcite, and pyrite. Yields from many of the wells that penetrate no deeper than the Dresbach are more than 500 gallons per minute although a considerable portion of the water is derived from higher formations. It is probably conservative to estimate that the Dresbach alone will furnish at least 200 gallons per minute without an excessive draw-down.²² Wells at Bensenville which furnish water with only 0.9 pound of encrusting solids per 1000 gallons draw to an undetermined extent on formations below the Dresbach but not above it. Anderson's²³ average of 57 analyses from wells in the Dresbach gives 5.2 pounds per 1000 gallons, but these wells are mainly uncased and draw to a large but unknown extent on the St. Peter and other formations. The water from the city well at Pawpaw carries less than 1.5 pounds.²⁴

EAU CLAIRE FORMATION

DESCRIPTION

The Eau Claire formation consists of fine-grained, dolomitic sandstone of gray and pink colors, calcareous shales of red, gray, and green colors called "marl" by drillers, and more or less sandy and shaly gray to blue dolomite. The sandstones are in many places hard enough to break in chips and are often logged as "lime". The upper limits of the formation may be distinguished by the change from clean sandstone to either shale or fine-grained dolomitic sandstone. The Eau Claire is noted for its variability and scarcely any two wells show the same succession in detail. Sandstone appears to be more abundant near the middle of the formation. The lower limit of the Eau Claire formation is difficult to determine in some logs, for there are local layers of shale as far down as the drill has penetrated; in general it should be placed at the bottom of the shale, dolomite, and fine-grained dolomitic sandstones. With this definition of the upper and lower limits of the formation, a thickness of from 300 to nearly 400 feet is obtained. The logs in Table 12 illustrate the character of the Eau Claire.

²²The subject of the relative draw-down or specific capacity of wells has not been investigated as the known data are contradictory. The writer believes that few wells in the Chicago district now furnish much more than 5 gallons per minute per foot of lowering except where some of the water comes from large opening or crevices.

²³Anderson, C. B., The artesian waters of northeastern Illinois: Illinois State Geol. Survey Bull. 34, p. 99, 1919.

²⁴Habermeyer, G. C., Public ground-water supplies in Illinois: Illinois State Water Survey Bull. 21, p. 501, 1925.

TABLE 12.—*Well logs illustrating character of the Eau Claire formation*

(a) Partial log of city well, Galena, Jo Daviess County		
	Thickness <i>Feet</i>	Depth <i>Feet</i>
		840
Sandstone, medium to fine grained, gray glauconitic.....	20	860
Sandstone, like above, with gray sandy shale.....	60	920
Sandstone, fine grained, gray, dolomitic, hard, some gray shale and pyrite	30	950
Shale, gray, sandy, dolomitic, pyritic	10	960
Sandstone, medium grained, gray, pink and red, dolomitic, glau- conitic, with greenish gray dolomitic shale.....	190	1150
Total Eau Claire 310 feet		
(b) Partial log of Chicago and Northwestern Railway well, West Chicago, Du Page County ^a		
	Thickness <i>Feet</i>	Depth <i>Feet</i>
		1430
Sandstone, coarse grained, gray, with blue dolomitic shale.....	25	1455
Shale, greenish blue, slightly dolomitic, sandy	25	1480
Shale, grayish blue, dolomitic	20	1500
Sandstone, coarse to very fine grained, light gray.....	15	1515
Shale, mixed gray and red, sandy, dolomitic.....	10	1525
Sandstone, medium to fine grained, gray to light pink, dolomitic, with gray dolomitic, glauconitic shale.....	30	1555
Sandstone, very fine grained, yellowish gray	10	1565
Sandstone, medium to fine grained, gray to light pink, with gray dolomitic glauconitic shale	30	1595
Shale, greenish blue, sandy, pyritic.....	10	1605
Dolomite, gray to dark blue, with dark gray glauconitic shale....	125	1730
Dolomite, white to light gray, with dark gray dolomitic and non- dolomitic shale layers	70	1800
Total Eau Claire 370 feet		
(c) Partial log of well at St. Mary's Academy, Des Plaines, Cook County		
		1115
Shale, gray, dolomitic	1	1116
Sandstone, fine grained, gray, dolomitic.....	24	1140
Sandstone, like above with gray shale.....	5	1145
No sample	5	1150
Sandstone, medium grained, gray, very dolomitic, glauconitic, with gray shale	15	1165
Shale, gray, dolomitic	10	1175
Sandstone, fine grained, gray, dolomitic, glauconitic, shaly.....	10	1185
Shale, gray, dolomitic	15	1200
Sandstone, very fine grained, gray, very dolomitic, hard.....	35	1235
Sandstone, like above with gray shale.....	5	1240
No sample	10	1250
Shale, gray, dolomitic	1	1251
Sandstone, very fine grained, gray, very dolomitic, with some gray shale	34	1285
Sandstone, fine grained, gray, dolomitic, glauconitic, with some gray dolomitic shale	65	1350

^aSamples examined by R. C. Lentz, Inspector.

(c) Partial log of well at St. Mary's Academy, Des Plaines,
Cook County (Concluded)

Sandstone, medium to very fine grained, gray and light pink, very dolomitic, some hard layers, some greenish gray dolomitic shale, some glauconite	50	1400
Sandstone, very fine grained, gray, very dolomitic and glauconitic	20	1420
Sandstone, fine to medium grained, gray and pink, dolomitic, hard, glauconitic	5	1425
Sandstone, fine, gray, dolomitic, glauconitic	5	1430
Shale, greenish gray, dolomitic, sandy	5	1435
Sandstone, fine to medium grained, gray and pink, dolomitic, hard	15	1450
Sandstone, fine grained, gray, dolomitic	20	1470
No sample	5	1475
Shale, gray, dolomitic	10	1485
Sandstone, fine grained, gray, dolomitic.....	5	1490
Total Eau Claire 375 feet		

(d) Partial log of Ogden Armour well, Lake Forest, Lake County

	Thickness <i>Feet</i>	Depth <i>Feet</i>
		1360
Sandstone, fine grained, pink, domolitic; with shale, red, dolomitic	10	1370
Sandstone, fine grained, gray, dolomitic; with green dolomitic shale	30	1400
Shale, sandy, pink to gray, slightly glauconitic, dolomitic.....	90	1490
Sandstone, medium to fine grained, gray, dolomitic.....	80	1570
Dolomite, mainly very sandy, gray; some glauconite.....	30	1600
Sandstone, fine grained, gray, very dolomitic, layers of greenish gray dolomitic shale	70	1670
Total Eau Claire 310 feet		

WATER SUPPLIES

The wells in the Chicago and North Western Railway yards at Proviso described by Anderson²⁵ are the only ones known to the writer which are so cased that they derive all of their water from the Eau Claire formation. They yield water with less than one pound of encrusting solids per 1000 gallons but at the cost of the excessive draw-down of one foot per gallon per minute. Locomotive engineers complain that this water foams. The foaming is apparently due to the large content of alkalies. At Western Springs²⁶ water from the Dresbach and Eau Claire formations contains nearly 6 pounds of encrusting solids in 1000 gallons. It is probable that the quality of water in the Eau Claire varies greatly but, as a whole, the formation yields little water. Unless it is desired to reach the underlying Mt. Simon sandstone it is inadvisable to drill into the Eau Claire farther than to form a settling basin for caved material from the overlying formations in the well.

²⁵Anderson, C. B., The artesian waters of northeastern Illinois; Illinois State Geol. Survey Bull. 34, pp. 116-120, 236, 297-298, 1919.
²⁶Habermeyer, G. C., Public ground-water supplies in Illinois: Illinois State Water Survey Bull. 21, p. 682, 1925.

DRILLING CONDITIONS

The writer has not learned of any particular difficulties that are met in drilling through the Eau Claire formation. The shales are firm enough in most localities to be left uncased. Some of the more dolomitic rocks drill very slowly.

MT. SIMON SANDSTONE

DESCRIPTION

The Mt. Simon sandstone is fine- to very coarse-grained; its finer portions are mostly gray and some of the coarser beds are pink or red. It is probable that the amount of coarse red sandstone increases with depth below the top of the formation as is indicated by the logs in Table 13. There are some thin layers of red and gray non-dolomitic shale which appear to be erratic in distribution. The Mt. Simon sandstone has never been completely penetrated in Illinois; the farthest that it has been entered, so far as the writer has been able to learn, is 842 feet at Dixon.

TABLE 13.—*Well logs illustrating character of the Mt. Simon sandstone*

(a) Partial log of Chicago and North Western Railway well, West Chicago, Du Page County ^a		
	Thickness <i>Feet</i>	Depth <i>Feet</i>
		1800
Sandstone, medium grained, white to light gray, pyritic.....	10	1810
Sandstone, medium to fine grained, white to light gray and pink; dolomitic in part	15	1825
Sandstone, coarse to fine grained, white to light gray, some pink	10	1835
Sandstone, coarse to very fine grained, white to light gray.....	15	1850
Sandstone, coarse to very fine grained, gray to yellowish gray, some pink layers	30	1880
Sandstone, coarse to very fine grained, pink.....	30	1910
Sandstone, coarse to very fine grained, gray to yellowish gray; with some pink layers	60	1970
Sandstone, coarse to very fine grained, light pink.....	50	2020
Sandstone, coarse to very fine grained, gray, yellow, and pink..	62	2082
Mt. Simon penetrated 282 feet.		
^a Samples examined by R. C. Lentz, inspector.		
(b) Partial log of city well No. 8, Rockford, Winnebago County		
		790
Sandstone, fine to medium grained, white.....	280	1070
Sandstone, fine to medium grained, gray, shaly.....	20	1090
Sandstone, fine to medium grained, white	30	1120
Sandstone, fine to very coarse grained, gray.....	35	1155
Sandstone, fine to medium grained, gray.....	5	1160
Sandstone, fine to very coarse grained, gray.....	10	1170
Sandstone, very fine grained, gray.....	20	1190
Sandstone, fine to very coarse grained, gray.....	70	1260
Sandstone, fine to very coarse grained, pink.....	10	1270
Sandstone, fine to very coarse grained, gray.....	20	1290
Sandstone, fine to very coarse grained, pink.....	10	1300
Sandstone, very fine to fine grained gray and yellow.....	20	1320
Sandstone, very fine grained, dark pink.....	90	1410
Sandstone, fine to very coarse grained, angular grains, dark pink	90	1500
Mt. Simon penetrated 710 feet		

(c) Partial log of wells at Dixon Epileptic Colony, near Dixon, Lee County^b

		1080
Sandstone medium grained, white, some glauconite and pyrite..	140	1220
Sandstone, coarse grained, white, some pyrite.....	50	1270
Sandstone, coarse to medium grained, gray, pyritic.....	50	1320
Sandstone, medium to very coarse grained, white and gray.....	30	1350
Sandstone, fine to very coarse grained, yellow to reddish brown	230	1580
Sandstone, fine to medium grained, white.....	44	1624
Sandstone, fine to medium grained, light pink and brownish yellow	38	1662
Sandstone, medium to coarse grained, pink.....	42	1704
Sandstone, coarse to exceedingly coarse grained, brownish red, yellow, pink, gray, subangular grains.....	76	1780
Sandstone and shale, dark red.....	3	1783
Sandstone, coarse to medium, pink	42	1825
Sandstone, medium to fine grained, dark red.....	38	1863
Sandstone, very coarse grained, red	8	1871
Sandstone, coarse to medium grained, pink.....	51	1922

Mt. Simon penetrated 842 feet

^bSamples described by C. B. Anderson and T. E. Savage.

WATER SUPPLIES

The coarse layers of the Mt. Simon sandstone furnish large quantities of water, sufficient in some localities to mask the character of the waters from higher formations. The very coarse layers are erratic in distribution and are interbedded with fine-grained sandstones which supply little water. It follows that adjacent wells may find different conditions even at the same stratigraphic level. As the Mt. Simon is drawn upon by fewer wells than are the higher formations, the level of the water in it has not yet been lowered to as great an extent. Allowance must be made for the fact that the diameter of many old wells was so small that they either supply little water from the deeper formations or have long since caved or "bridged" at higher levels. For instance, it was noted that the old well of the Chicago and North Western Railway at West Chicago did not interfere with the new well about 25 feet away after the St. Peter had been cased off in the latter; this lack of interference demonstrated that the old well had caved below the St. Peter. The waters of the Mt. Simon are in general more highly mineralized than are those from higher formations²⁷ if total solids alone are considered, but for the most part they contain less encrusting solids than do the shallower waters. The water from the Mt. Simon at Western Springs contains about 3 pounds of encrusting solids per 1000 gallons. Less than 2 pounds in the same quantity is reported at Galena.²⁸ The depth

²⁷Anderson, C. B., The artesian waters of northeastern Illinois: Illinois State Geol. Survey Bull. 34, p. 102, 1919.

²⁸Habermeyer, G. C., Public ground-water supplies in Illinois: Illinois State Water Survey Bull. 21, pp. 239, 683, 1925.

at which salt water appears varies greatly from place to place but the fact has been given comparatively little attention as wells are now rarely drilled deep enough to strike such water. It appears probable that this condition is due to the lenticular character of the coarse layers so that flushing has extended to different depths in various places. The presence of wells that have artificially accelerated the circulation is also important. As a general rule salt water is to be feared in the Chicago district at any depth greater than 2000 feet although there are several successful wells of greater depths. Contrary to popular ideas the contact between fresh and salt waters is relatively abrupt. The best way to guard against drilling into salt water is to take samples of water from the bottom of the hole with either the bailer or the sand-pump. If a sample runs more than 150 parts per million of chlorine, the well should be stopped. If the water on pumping is too high in salt, then a filling of cement should be placed to a level above the salt-water stratum.

DRILLING CONDITIONS

Except for local caving layers no particular drilling difficulties in the Mt. Simon sandstone have come to the attention of the writer.

STRUCTURE

INTRODUCTION

Although generally thought of as horizontal, the strata of northern Illinois are inclined at angles which range from a few minutes to 50 degrees. Steep dips are found in: (1) the monoclinial fold which passes west of Streator through La Salle and flattens out toward the northwest (the west limb of the La Salle anticline); (2) the vicinity of Oregon; and (3) a small district near Des Plaines. The La Salle anticline itself, distinguished from its western slope, is the southward continuation of the broad Wisconsin arch. On it there are several small domes and its flanks are crenulated with minor synclines and anticlines whose axes lie approximately east and west.

The position of the different rock formations in an area of comparatively gentle dips is best shown by contours drawn on top of a certain easily identified formation. These contours represent what would be the surface of the land if all overlying formations of rock and soil were stripped off. Except as it controls the position of the outcrops of rock formations which are resistant to weathering and erosion, the structure is independent of the present configuration of the surface. In Illinois much of the present topography is the result of deposition of loose material by glaciers and not of the wearing away of the bed rocks; the northwestern part of the State, however, was not glaciated. It is difficult for persons not experienced in geology to grasp the idea that (a) the same rock formation is not found at the same depth at all places, and

(b) undulations in the bed rock formations are not necessarily, or indeed commonly, reflected in the shape of hills and valleys. Plate I was constructed on the basis of elevations of the top of the Dresbach sandstone obtained from the wells tabulated in Table 14. As the number of wells is insufficient to permit accurate location of the contours, a study of the interval between the top of the St. Peter and the top of the Dresbach was made. This varies from less than 300 feet to nearly 1000 feet; the increase is from northeast to southwest with only a few minor irregularities some of which may be due to erroneous well logs. The greatest uncertainty in the determination of this interval is in the western and southern parts of the map. With this interval as a basis, the observed elevations were supplemented by records of wells that go no deeper than the St. Peter and by the structure map prepared by Cady²⁹ to show the top of the formation. If more records of shallow wells in northern Illinois were available the map would be more satisfactory but this region has not been studied in recent years.

Plate II is a section along the line of the Chicago and North Western Railway from Clinton, Iowa, to Chicago. The vertical scale is exaggerated about 70 times so that the inclination of the rock is shown at much too great an angle in order to make the scale of the well logs large enough to give the necessary information. Lines between wells simply connect similar formations and do not necessarily indicate the variations in the formations between the points of observation. No attempt has been made to show the surface either of the ground or of the bed rock.

STRUCTURAL FEATURES

Attention has already been called to the La Salle anticline which separates the northeastern region of relatively elevated strata from the deep basin to the southwest. On account of the increase in the St. Peter-Dresbach interval toward the southwest, this basin is much deeper than that in the top of the St. Peter. Little is known of the forms in the deeper strata of the comparatively abrupt domes of the region near Dixon and Oregon. Just north of these, along the Stephenson-Ogle county line, is a marked syncline which extends entirely across the State. Its exact shape is not known in the western part of the area and there may be no such enclosed basin as is shown around Freeport. The abnormal course of Pecatonica River is probably related in part to this flexure. The syncline is best developed in McHenry and Lake counties.

South of this syncline is an anticline which can be traced from the vicinity of Savannah, Carroll County, east through the domes at Forreston and Leaf River, Ogle County, to just north of Des Plaines, Cook

²⁹Cady, G. H., Structure of the La Salle anticline: Illinois State Geol. Survey Bull 36, pp. 85-179, 1920.

TABLE 14.—Well data used in the construction of the structure map (Pl. I)

County	Well	Map No.	Surface Elev. Feet	St. Peter		Dresbach		Interval Feet
				Depth Feet	Elev. Feet	Depth Feet	Elev. Feet	
Boone								
Belvidere, city	755	340	+415	725	+30	385
Carroll								
Mt. Carroll, city	1	812	360	+452	910	-98	550
Savannah, city	2	592	355	+237	945	-353	590
Cook								
Argo, Corn Products Co.	33	590	800	-210	1345	-755	545
Berwyn, city	25	605	845	-240	1370	-765	525
Blue Island, city	35	641	909	-268	1450	-809	541
Chicago								
Armour Glue Works.	29	590	918	-328	1468	-878	550
Burke and James.	20	590	915	-325	1420	-830	505
Fortune Bros. Brewing Co.	19	590	890	-300	1440	-850	550
Godfrey Yards, C. M. & St. P. Ry.	8	612	800	-188	1260	-648	460
Gottfried Brewing Co.	27	590	897	-307	1420	-830	523
Mayer, Oscar	10	590	700	-110	1325	-735	625
National Brewing Co.	22	590	878	-288	1391	-801	513
Sears Roebuck and Co.	17	590	853	-263	1361	-771	508
South Side Brewery.	28	590	965	-375	1450	-860	485
Spielman Bros.	9	590	895	-305	1390	-800	495
U. S. Brewing Co.	18	590	885	-295	1448	-858	563
White Eagle Brewery.	21	590	880	-290	1402	-812	522
Chicago Heights, city	36	694	1005	-311	1685	-991	680
Des Plaines								
Crotian Orphanage	5	635	1010	-375	1575	-940	565
Norma Yards, C. and N. W. Ry.	655	700	-45	1025?	-330?	325?
St. Mary's Academy.	2	640	505	+135	965	-325	460
Forest Park, city	23	615	932	-317	1465	-850	533
Glenview, North Shore Country Club.	3	635	840	-205	1260	-625	420
Hawthorne, C. B. and Q. Rr.	26	605	845	-240	1450	-845	605
Hillside, Mt. Carmel Cemetery.	15	700	760	-60	1320	-620	560

La Grange, city.....	30	645	800	-155	1370	-725	570
Maywood, Govt. Hospital.....	16	630	818	-188	1345	-715	527
Melrose Park, city.....	13	630	780	-150	1370	-740	590
Morton Grove, city.....	4	628	845	-217	1275	-647	430
Oak Park, city.....	11	630	900	-270	1415	-785	515
Orchard Place, Twin Orchard Country Club	7	655	750	-95	1220	-565	470
Park Ridge, city.....	6	660	820	-160	1250	-590	430
Proviso, C. and N. W. Ry.....	14	644	810	-166	1330	-686	520
River Forest, city.....	12	630	890	-260	1400	-770	510
Riverside, city	24	610	825	-215	1375	-765	550
South Chicago, Illinois Steel Co.....	34	590	965	-375	1520	-930	555
Summit, city	32	600	804	-204	1340	-740	536
Western Springs	31	648	790	-142	1337	-689	547
Winnetka, city	1	651	939	-288	1310	-659	371
DeKalb							
DeKalb, city .....	.....	865	524	+341	1180	-315	656
DuPage							
Bensenville, C. M. and St. P. Ry.....	1	680	805	-125	1260	-580	455
Downers Grove, city.....	6	717	817	-100	1435	-718	618
Elmhurst, city	2	677	787	-110	1270	-593	483
Lombard, city	3	745	730	+15	1250	-505	520
Naperville, city	5	677	646	+31	1265	-588	619
West Chicago, C. and N. W. Ry.....	4	760	700	+60	1285	-525	585
Grundy							
Sec. 25, T. 34 N., R. 6 E.....	.....	540?	277	+260?	1149?	-600?	877?
Henry							
Geneseo, city	1	645	1075	-430	2035	-1390	960
Kewanee, city	2	850	1320	-470	2330	-1480	1010
Jo Daviess							
Galena, city	1	600	155	+445	700	-100	545
Hanover, city	2	632	333	+299	920?	-290?	589?
Kane							
Aurora, city	5	740	585	+155	1175	-435	590
Batavia, city	4	660	520	+140	1100	-440	580

TABLE 14—Well data used in the construction of the structure Map (Pl. I)—(Concluded)

County	Well	Map No.	Surface Elev. Feet	St. Peter		Dresbach		Interval Feet
				Depth Feet	Elev. Feet	Depth Feet	Elev. Feet	
Elgin, city	2	738	560	+178	1050	-312	490
	Hampshire, city	1	900	610	+290	970	-70	360
	St. Charles, city	3	696	560	+136	1100	-404	540
Kendall								
Near Plano								
		575	385	+190	1110	-535	725
Lake								
Area (Mundelein), St. Mary's Sem'y...								
	5	700	860	-160	1240	-540	380
Blodgett, C. and N. W. Ry.								
	7	650	805	-155	1125	-475	320
Grays Lake, city								
	2	800	900	-100	1200	-400	300
Lake Forest, Ogden Armour								
	6	690	930	-240	1240	-550	310
North Chicago, Abbott Laboratories..								
	3	763?	880	-207?	1190	-517?	310
Rondout, Katherine Kreig Budd Me-								
	4	678	864	-186	1219	-541	355
morial Home for Children								
	1	648	850	-202	1160	-512	310
Zion City, city								
La Salle								
Mendota, city								
		750	360	+390	990?	-240?	630?
Ottawa, city								
	2	484	Outcrop	.....	960	-476	960+
Ottawa Silica Co.								
	3	490	.....	+510	1010	-520	1030
Sec. 32, T. 34 N., R. 5 E.								
	1	710	359	+351	1266	-556	907
Streator, city								
	4	623	444	+179	1237	-614	793
Lee								
Amboy, city								
	3	752	180	+570	970?	-220?	790?
Dixon, city								
	2	660	160	+500	806	-146	646
Dixon, Epileptic Colony								
	1	760	95	+665	724	+36	629
Pawpaw, city								
	4	885	.....	.....	928	+43	.....
McHenry								
Woodstock, city								
		915	796	+119	1204	-289	408
Mercer								
Aledo, city								
		738	1180	-442	2147	-1409	967

Ogle									
Byron, city	1	730	.....	.....	640	+90	.....	
Mt. Morris, city	2	916	156	+760	735	+181	579		
Rochelle, city	3	793	45	+748	704	+89	659		
Rock Island									
Rock Island, Prospect Park	.....	611	1091	-480	1980	-1369	889	
Will									
Joliet, city	4	552	620	-68	1330	-778	710		
Joliet, penitentiary	3	645	700	+55	1420	-775	730		
Lockport, city	2	568	630	-62	1310	-742	680		
Plainfield, city	1	601	615	-14	1302+	-701+	687+		
Winnebago									
Rockford, city No. 8	.....	728	Outcrop	.....	570	+158	330+
Whiteside									
Morrison, city	1	670	760	-90	1500	-830	740		
Sterling, city	2	645	550	+95	1175	-530	625		
State of Wisconsin									
Beloit, Wisconsin Power and Light Co.	1	745	.....	.....	380	+365	.....	
Genoa Junction, city	4	845	690	+155	945	-100	255		
Sharon, city	2		470	+517	785	+202	315		
Walworth, city	3	995	680	+315	980	+15	300		
State of Iowa									
Dubuque, Schmidt Brewery	1	630	114	+516	730	-100	616		
Clinton, city No. 6	2	588	700	-112	1445	-857	745		

AUTHORITIES

¹Anderson, C. B., The artesian waters of northeastern Illinois: Illinois State Geol. Survey Bull. 34, 1919.
²Bretz, J. H., Geology and mineral resources of the Kings quadrangle: Illinois State Geol. Survey Bull. 43, p. 225, 1923.
³Habermeyer, G. C., Public ground-water supplies in Illinois: Illinois State Water Survey Bull. 21, 1925.
⁴Norton, W. H., et al, Underground water resources of Iowa: U. S. Geol. Survey Water-Supply Paper 293, 1912.
⁵Savage, T. E., and Udden, J. A., The geology and mineral resources of the Edgington and Milan quadrangles: Illinois State Geol. Survey Bull. 38C, pp. 17-18, 1921.
⁶Udden, J. A., Some deep borings in Illinois: Illinois State Geol. Survey Bull. 24, 1914.
⁷Unpublished records in files of Illinois and Wisconsin Geological Surveys.

County, and which is an extension of Cady's "Savanna-Sabula anticline". At Des Plaines the south limb of this fold is apparently marked by a fault which farther east seems to pass into a monocline and to the south of which is a small basin. The evidence of faulting is the broken condition of the rocks in the Des Plaines city well, determined both by examination of the samples and from information given by the driller. Great difficulty was experienced in drilling this well and after several liners were side-tracked the well was cased to the bottom at 1600 feet. The cuttings from the sandstones were muddy and little water could be obtained. In addition, the Prairie du Chien dolomite appears to be absent so that the evidence favors the view that this well passed through a south-dipping normal fault. About a mile and a half to the east the well at the Croatian Orphanage encountered somewhat similar conditions and very little water was found at any depth. A well at the city hall was reported as finding "shale" to a depth of 1800 feet.³⁰ Where cuttings have been examined, however, it has been found that the formations occur in the usual order, although much broken, and in the Orphanage well with thicknesses about 30 per cent greater than the normal thickness for the vicinity. The latter fact suggests that in places the fault passes into a monocline with the strata dipping at a considerable angle. The St. Peter sandstone is 500 feet deeper at the Orphanage than at St. Mary's Academy, only a trifle more than two miles to the north. Whatever the true explanation of these phenomena may be, the writer advises that well drillers avoid an east-west belt through the southern part of Des Plaines for several miles in each direction.

Farther south there is a marked syncline in northern Kendall County which strikes northwest-southeast. This is associated with an offshoot of the Wisconsin anticline which extends southeast from the Oregon dome through the St. Peter outcrops in northeastern La Salle County to Kankakee, and which was named the Kankakee anticline by Cady.³¹ Southwest of the Kankakee anticline a syncline passes through Grundy County and separates the anticline from the true La Salle anticline east of La Salle and Streator which has a more nearly north-south strike.

Although it cannot be expected that the structure map will prove to be absolutely accurate at all points, it serves as a basis for correlating and evaluating the known data so that estimates of the depth to the top of the Dresbach sandstone can be made on a definite and concrete basis.

³⁰Habermeyer, G. C., Public ground-water supplies in Illinois: Illinois State Water Survey Bull. 21, p. 174, 1925.

³¹Cady, G. H., The structure of the La Salle anticline: Illinois State Geol. Survey Bull. 36, p. 133, 1920.

The intervals shown serve as a check, for when the top of the St. Peter is reached they allow of an estimate of the distance to the top of the Dresbach.

CAUSE OF DEFORMATION

Judging from the conditions around the partly exhumed pre-Cambrian monadnocks of Wisconsin and modern theories of the origin of folds in the mid-continent oil fields, the structural features of northern Illinois are probably due to irregularities in the pre-Cambrian basement. Cady concluded that the La Salle anticline "is strongly suggestive of an initial line of weakness . . . possibly due to a concealed fault line which may be present in the deeply buried rocks . . ."³²

WATER QUALITY AND PROBLEMS

GENERAL STATEMENT

It is impossible with present knowledge fully to discuss the quality of the waters in the several formations. It so happens that a number of persons who have been exploring for softer waters than those furnished by ordinary uncased wells are not at present willing to reveal all the information that they have collected at considerable expense. Some of the methods of casing wells are regarded as trade secrets as they are not followed by all well drillers. Nevertheless, some facts are so well known that they can profitably be recapitulated.³³

NATURE OF SOFT WATERS

The waters of northern Illinois generally increase in total solids with depth, but the character of the bases present varies greatly. Near the surface alkaline earths (calcium and magnesium) predominate but with depth alkalies (sodium and potassium) increase in amount. This increase is for the most part accompanied by larger amounts of chlorides and sulphates. Very deep waters are foaming, corrosive, and undrinkable but some intermediate waters contain only a moderate amount, less than one pound per 1,000 gallons, of encrusting solids. The waters also vary in amount of sulphate which when combined with calcium or magnesium makes the most objectionable form of scale in boilers. The mineral character of the waters is also related to the kinds of rocks from which they come and in general the best water comes from pure quartz sandstones. The cause of the decrease in alkaline earths with depth is not as yet definitely known. It is quite possible that the work of Renick³⁴

³²Idem, p. 179.

³³Anderson, C. B., The artesian waters of northeastern Illinois: Illinois State Geol. Survey Bull. 34, pp. 100-101, 116-120, 140, 142, 236; 297-298, 300, 1919.

Habermeyer, G. C., Public ground-water supplies in Illinois: Illinois State Water Survey Bull. 21, 1925.

³⁴Renick, B. C., Base exchange in ground water by silicates as illustrated in Montana: U. S. Geol. Survey Water-Supply Paper 520: pp. 53-72, 1924.

in Montana may prove to explain the phenomenon as one analogous to that alteration which takes place in a zeolite water-softener.

METHODS OF TESTING QUALITY OF WATER

The ideal method of testing the quality of the water from different formations is to set casing down to the top of the stratum and then make a pumping test. The expense of such a procedure generally prohibits following it so that it is customary to take samples of water with a bailer or sand-pump. Some of the results thus obtained do not show the true character of the water in the formation which the bottom of the well has reached when the sample is taken. The principal causes of such failure are: (a) The head of water is greater in the shallow formations than in the deep ones so that surface waters run down the well and force away the deep-seated waters. (b) The valve in the bottom of the bailer leaks. (c) The bailer is short and allows the mixture of waters at the top while hoisting. (d) The waters diffuse as a result of drilling operations or of a long wait after drilling which allows circulation due to thermal differences. The writer has noted diffusion of waters when taking temperatures in a 12-inch hole. The sand-pump is preferable to the bailer in that its top is closed although there is danger that a change in rate of lowering may cause it to open before the bottom of the run is reached. Experience has shown that tests of water obtained in this manner are reasonably reliable only when the water level is constantly rising as the well is drilled deeper. Then they are checked by pumping tests within a reasonable margin of error. Such tests are worthless (a) when the water level falls as the well is deepened and (b) when the lower formations carry little water. In judging of the quality of water which will be obtained on completion of the well it must be realized that (a) bailer tests show nothing as to the yield of the different formations, and (b) many wells yield better water after prolonged pumping as a result of the artificial acceleration of the flow of water which washes out the more soluble substances.

The following deep wells are reported as yielding water with less than two pounds of encrusting solids per 1,000 gallons:

Chicago, Milwaukee and St. Paul Ry., Bensenville.
 Chicago and North Western Ry., Proviso and West Chicago.
 St. Mary's Seminary, Area (Mundelein).
 St. Mary's Academy, Des Plaines.
 Ogden Armour, Lake Forest.
 Abott Laboratories, North Chicago.
 Waterworks, Batavia, Bensenville, Hanover, Morrison, Pawpaw, Riverside,
 St. Charles.³⁵

The Bensenville railroad wells are cased to the Dresbach, and the Proviso wells to the Eau Claire; the others either have a confidential

³⁵Habermeyer, G. C., Public ground-water supplies in Illinois: Illinois State Water Survey Bull. 21, pp. 57, 274, 436, 501, 551, 582, 1925.

casing log or obtain so much water from low formations that the lack of casing is not apparent. The yields from some of these wells is as much as 600 to 800 gallons per minute. It must be realized that the construction of a soft water well near an uncased well is nearly impossible because waters from several formations may pass through the latter and thus reach the cased well.

CONTAMINATION OF DEEP WELLS

Flowing wells are safe, even if not cased through contaminated upper formations, as above the artesian stratum the flow of water is outward from the well. In the Chicago district the deeper waters now have a head far below that of the shallow waters. In such circumstances casing with a good shut-off at the bottom is essential to a safe water supply. Two wells are known of where very bad water was obtained at depths greater than 1,000 feet. The tests in each well showed a good shut-off below the Maquoketa shale, but during drilling bad smelling water was observed to come from crevices in the Prairie du Chein formation. It has been suggested that sewage is being emptied into some abandoned well which is possibly many miles from the locations of these contaminated wells. In one well a packer set in the Mazomanie sandstone removed the trouble, but no information has been received as to the other well although it has been worked on for several years.

WELL CONSTRUCTION

No exhaustive discussion of methods of well construction can be attempted here.³⁶ Engineers are urged to devote careful attention to the quality of the casing and to the shut-off at the bottom of each string of pipe. It is not enough simply to drop pipe into a hole either with or without casing shoe. The character of the rock in which the shoulder is made must be considered, and brittle, fractured formations avoided. Large crevices are most common near abrupt changes in the character of the rock. It must be realized that holes of different sizes are rarely concentric and that lead seals between different sizes of pipe make joints of indifferent quality. It is far better to follow oil well practice and have the last string of pipe extend to the surface. Shut-offs in water wells may be tested by (a) placing a dye (fluorescein) in the water

³⁶More information on well drilling methods can be obtained from:
Bowman, Isaiah, Well-drilling methods: U. S. Geol. Survey Water-Supply Paper 257, 1911.

Day, J. H., Handbook of the petroleum industry, New York, 1922.

Jeffry, W. H., Deep well drilling, Toledo, 1921.

Sanderson, R. R., Drill work, methods and costs, Cyclone Drill Co., 1911.

Thompson, A. B., Oil field development, pp. 307-409, New York, 1916.

Uren, L. C., Textbook of petroleum production engineering, pp. 89-143, 201-301, New York, 1924.

Woodworth, R. B., The evolution of drilling rigs: Amer. Inst. Min. Eng. Trans., vol. 54, pp. 216-268, 1915.

Ziegler, Victor, Oil well drilling methods, New York, 1923.

between the different strings of pipe, and (b) observing the water levels inside and outside a string of pipe when the level is changed in the inner pipe by pumping or bailing. An excellent shut-off may be made by cementing the bottom of each string of pipe. This is best done before the hole is drilled any deeper but many drillers prefer to leave casing until all drilling has been completed for fear that in a crooked hole the wire line will wear through the pipe. It is advisable to use cement thick enough to protect the well from contaminated waters even without any pipe; this should extend from the surface through all contaminated waters. At lower levels many prefer clay instead of cement since that does not prevent the withdrawal of rusted pipe. Cementing of well casing is now standard practice in oil wells and its adoption in water wells is worth careful consideration.³⁷ Although the use of "genuine wrought iron" pipe is far preferable to that of the mild steel known to the trade as "wrought iron," it is well to remember that the best pipe will rust out in time since the waters from great depths, with the relief of pressure on being brought to the surface, evolve much carbon dioxide. In wells pumped directly into the mains this evolution of gas often causes foamy water as well as the precipitation of calcium carbonate. Where the air lift is employed, these processes take place in the tank and some of the dissolved iron is also oxidized and settles out. The freeing of gas is more pronounced in wells which are cased to great depths since all of the water comes from formations where the gas was under high pressure. Some cases of precipitation may be due to mingling of waters from different formations. Engineers should remember that although the methods employed in well drilling and construction appear very simple, their practical application finds every well a different engineering problem. Although the geological formations may be the same, the number and position of fractures, and variations in hardness and in porosity call for different procedure. In judging costs it should be realized that drilling in holes full of water is necessarily much slower than in oil wells, where water is excluded as far as possible, because the friction on the cable and tools lessens the force of the blows. Another point is that the efficiency of drilling depends to a great extent on the quality of the tool dressing; a poor tool dresser can slow down the work to a remarkable extent. A rule of primary importance is that the hole should be kept large enough to allow for unforeseen caves which entail reduction after the insertion of liners. Many engineers insist on butted joints in drive pipe, but most drillers prefer ordinary joints which may be tightened from time to time by screwing up the pipe. It is said that

³⁷Tough, F. B., Methods of shutting off water in oil and gas wells: U. S. Bur. Mines Bull. 163, 1918.

Kirchoffer, W. G., Grouting wells in rock formation effective and simple: Engr. News-Record, vol. 81, p. 367, 1918.

if drilling is properly done, very hard driving that might injure the threads can be avoided. Liners in the rock should not be driven; the need to drive them indicates a crooked hole. Attention should be drawn to the fact that crooked holes are more common in large than in small diameters since in the former there is more room for the drill stem and jars to swing to one side of the hole. As a general thing engineers should be slow to criticise the methods of experienced drillers for such methods are the result of years of practice rather than of theory. Well drilling is an art that demands experience and ingenuity; it is an operation in which, many times, the personal factor is more important than the quality of the machinery. The lowest bidder is often the most expensive in the long run.

FUTURE OF UNDERGROUND WATERS

Many wells have been abandoned in Illinois and elsewhere because it was assumed that the supply of water had been exhausted. Study of old wells shows definitely that for the most part they were of such small diameter that they soon bridged or filled with cavings. In some communities, when more water was required new wells were drilled so close to the older ones that the available supply was simply divided. It is absolutely essential that wells be spaced over considerable areas. In Chicago the water levels have been greatly lowered as has been shown by Anderson.³⁸ The condition appears to be local, although it was noted that at West Chicago, 30 miles away, the water in the Dresbach is now lower than the level of Lake Michigan. The reduction in water pressure has probably resulted in settling and compacting of the sandstones so that the porosity of the rocks has been permanently lessened. The situation in the Stock Yards district is serious and from the standpoint of conservation it seems a pity that such vast quantities of pure water are used for washing, cooling, boilers, and other industrial purposes for which lake water would serve as well. It is probable that in smaller cities sufficient water for a public supply will always be available. To this end the use of underground waters for industries that do not require pure water should be discouraged in the future, at least where surface waters are obtainable at reasonable cost.

Before concluding that public supplies from wells must be abandoned, engineers should look to see if the shortage cannot be relieved by repair of the wells. Methods of increasing the supply from old wells comprise recasing, cleaning, reaming, shooting, and deepening. Many drillers state that reaming is in most cases more expensive than a new well and that shooting, although an undoubted benefit if crevices are opened in the more brittle rocks, often causes permanent caving condi-

³⁸Anderson, C. B., The artesian waters of northeastern Illinois: Illinois State Geol. Survey Bull. 34, pp. 93-95, 1919.

tions which soon offset the increase of yield. The writer therefore hesitates to recommend shooting as a certain means of increasing well yields.³⁹

WELL LOGS

The writer wishes to emphasize the desirability of obtaining accurate well logs based both on drillers' records and on the study of cuttings from every 5-foot screw. Bags for the collection of samples are furnished free by the State Geological Survey at Urbana. Records based on examination of samples by an experienced geologist furnish much more detailed data than can be obtained from the drillers' log alone, but the latter should not be neglected, for in many cases the action of the tools may tell as much concerning the underground conditions as do the samples. It is a common fallacy among both geologists and engineers to think that samples from churn drill holes are worthless on account of caving. Such is not the case, for if caving equaled the amount of new hole little progress would be possible. Although it is true that caved material is sometimes troublesome in the study of cuttings, it can generally be distinguished by the large size and unworn character of the fragments and its presence can always be noted by an experienced driller. The principal source of error is the tendency of drillers to take samples from the slush pit when going off shift instead of direct from the bailer.

Records should include a casing log which shows the length and position of each string of pipe as well as the sizes of pipe and of hole. Whenever repair work or new wells are needed such detailed records are of immense value. Attention should also be given to the fact that study of underground temperatures is a guide to the relative amounts of water from different producing formations. Many temperatures of waters were collected by Anderson and Habermeyer⁴⁰ which, when compared with those observed by R. C. Lentz⁴¹ at West Chicago, seem to indicate that much water is derived by uncased wells from the formations above the Dresbach sandstone.

The State Water Survey Division has many records of well yields and analyses of water samples which are available to persons who contemplate installing wells. For municipalities, mineral analysis of waters will be made free of charge and assistance will be given during tests of yields whenever possible.

³⁹Norton, W. H., Underground water resources of Iowa: U. S. Geol. Survey Water-Supply Paper, 293, p. 131, 1912.

Kirchoffer, W. G., Increasing the capacity of ground water supplies: Amer. Water Works Assoc. Jour., vol. 15, pp. 144-151, 1926.

⁴⁰Anderson, C. B., The artesian waters of northeastern Illinois: Illinois State Geol. Survey Bull. 34, pp. 42-50, 1919.

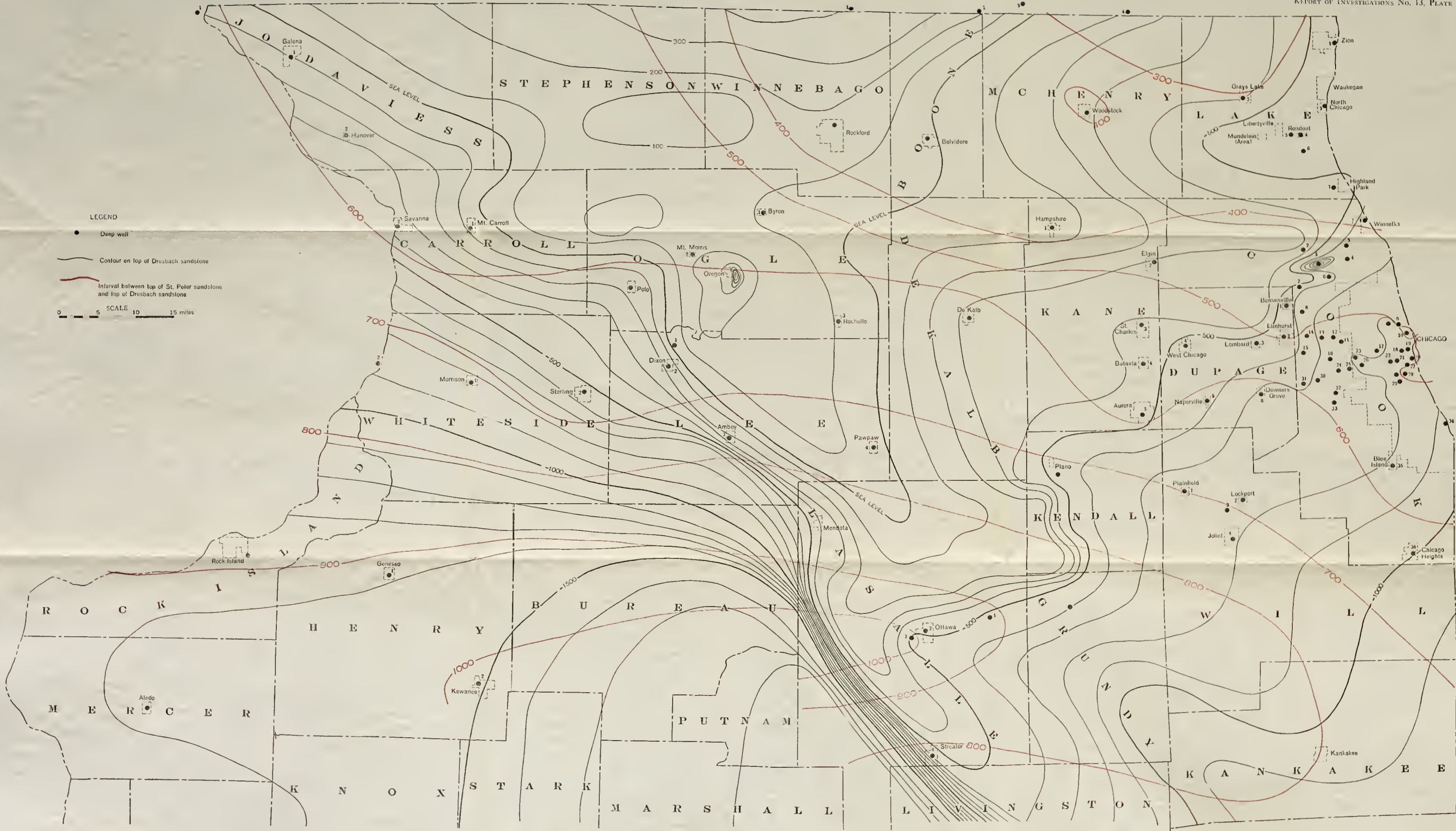
Habermeyer, G. C., Public ground-water supplies in Illinois: Illinois State Water Survey Bull. 21, 1925.

⁴¹Temperature at 1650 62° F., at 2082 75° F. Temperature in well at Madison, Wis., at 840 55° F.

In conclusion the writer wishes to urge that engineers and well owners cooperate with the State Geological Survey and the State Water Survey in collecting accurate data regarding underground waters. There can be little serious question but that a properly constructed well is a nearly fool-proof source of pure water with which no man-made filter can compare in efficiency and safety.

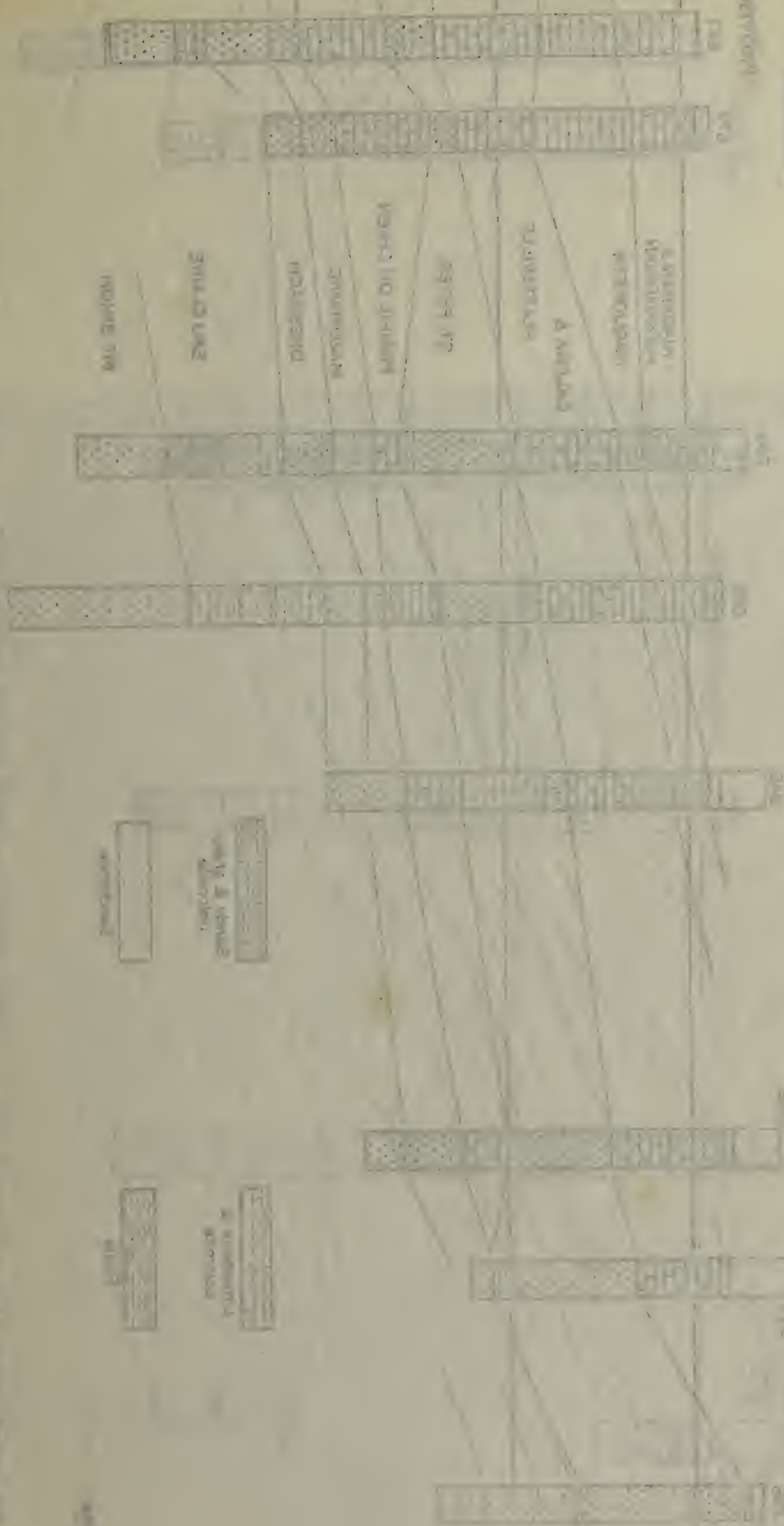
PLATE ONE

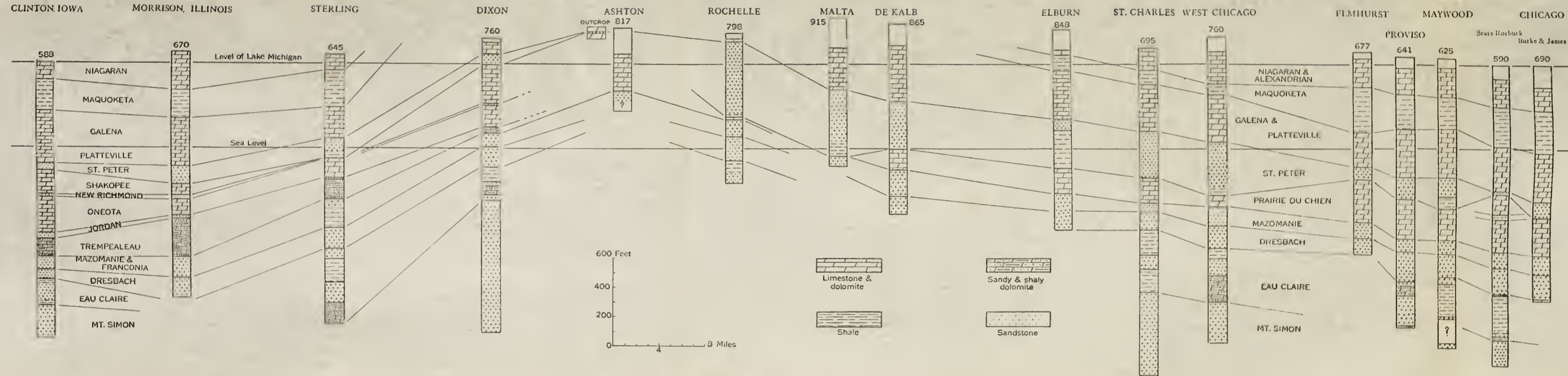




Structure map of northern Illinois. See table 14, pp. 36-39, for data used in the construction of the map.

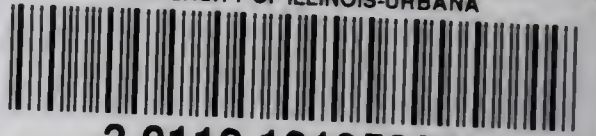
PLATE TWO





Section from Clinton, Iowa, to Chicago, Illinois. Lines between wells connect similar formations and do not attempt to show all the variation between the points where information is available. Vertical scale exaggerated about 70 times.

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